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Supplemental Final Environmental Impact Statement

Bozeman Municipal Watershed Project

Bozeman Ranger District, Gallatin National Forest
Gallatin County, Montana

Looking north from the BMW Project area between the Hyalite and Leverich Creek divide toward Bozeman, MT.

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Bozeman Municipal Watershed Project
Final Supplemental Environmental Impact Statement
Gallatin County, Montana

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Abstract: The Supplemental Final Environmental Impact Statement (SFEIS) presents supplemental analysis to the Final EIS. The need for additional information resulted from an administrative appeal review in June 2010 and court decisions since the Final EIS and Record of Decision in March 2010. The court decisions had direct bearing on the standards and analysis for this project. This Supplement presents new information on elk and other big game species, fisheries, sensitive plants, soils, water quality and consideration of reasonably foreseeable actions identified since March 2010. The supplemental analysis generally discloses reduced impacts to these resources as compared to effects previously discussed; and affirms previous conclusions about the potential alternatives and compliance with current direction.

Six alternatives were considered: All alternatives except the No Action were designed in whole or in part to address the purpose and need for action. Alternative 1 – No Action, Alternative 2 – Proposed Action, Alternative 3 – increased treatment and effectiveness from the proposed action, Alternative 4 – Prescribed burning emphasis with small tree thinning, Alternative 5 – mitigation for scenery, west slope cut throat trout and water quality, Alternative 6 – mitigates for scenery, west slope cut throat trout and water quality while recognizing the implementation limitations associated with helicopter logging. Alternative 6 is the preferred Alternative in the FEIS. Alternative 4 is the environmentally preferred alternative but was not selected because it does not meet the purpose and need as aeffectively as other alternatives.

The Final Environmental Impact Statement (March 2010) contains all other supporting analysis. A Record of Decision will be released concurrently with the SFEIS. A notice of availability will be published in the Bozeman Daily Chronicle, which will initiate a 45 day administrative appeal period. Notice of Availability for the SFEIS will also be in the Federal Register.

Summary

Changes between the FEIS and SFEIS. The summary is updated to include information since the release of the FEIS and Record of Decision in March 2010.

The Gallatin National Forest proposes to implement fuels reduction activities to reduce the potential for severe and extensive wildfire in the Bozeman Creek and Hyalite Creek drainages. The area affected by the proposal includes the City of Bozeman Municipal Watershed. This action is proposed because of the fuel conditions in the drainages, which consist of forested stands of generally mature timber. Analyses and fire risk assessments of the area concluded there is a high risk to the integrity of the watershed should there be severe and extensive wildfire. This would affect the quality of the water for Bozeman's domestic use, it would cause a safety concern for the recreating public and firefighters, and a wildfire started on the National Forest system (NFS) lands could enter into the wildland urban interface to the north of the forest boundary.

The Forest Service has worked with the City of Bozeman and other interest groups to develop the issues and alternatives for the Final Environmental Impact Statement. The six alternatives address the significant issues by varying the types of fuel reduction treatments and the amount of acreage treated. These activities include partial thinning in mature stands, thinning of excess standing fuels in small diameter regenerated forest, and broadcast burning in less dense forest. Each of these alternatives accomplishes the purpose of the project in different ways and each has differing effects on resources such as water quality, scenic quality, fisheries and soils.

In March 2010 a Final EIS and Record of Decision was released for this Project. Two administrative appeals were received on the Decision. As a result of the administrative review, the decision was remanded to the Forest because it was not clear how the analysis was consistent with the Regional Soil Quality Standards. The appellants also raised some important issues related to water quality. Because the water quality analysis was significantly revised, the fisheries analysis was also revisited. At about the same time three court decisions were made resulting in the need for additional consideration of issues specific to the Gallatin Forest Big Game standard (USDA, 1987 p. II-18), and the Clean Water Act exemption for forest roads. Since March 2010, additional information became available related to reasonably foreseeable activity on adjacent lands. Those actions were considered for potential cumulative effects with the Bozeman Municipal Watershed Project. The SFEIS is limited to a compilation of these reviews, additional analysis and a correction related to sensitive plants. The supplemental analysis discloses reduced impacts to these resources compared to the analysis in the FEIS. The additional data and analysis affirms conclusions and alternative development previously disclosed in the FEIS. A Record of Decision will be released concurrently with the SFEIS. A notice of availability will be published in the Bozeman Daily Chronicle, which will initiate a 45 day administrative appeal period. Notice of Availability for the SFEIS will also be in the Federal Register.

Based upon the effects to Alternatives disclosed in this supplemental analysis and other effects disclosed in the FEIS, the Responsible Official will decide whether to implement fuel reduction activities to meet the purpose and need for action; if so, which alternative and associated activities would be implemented. Alternative 6 is the preferred Alternative in the FEIS. Alternative 4 is the environmentally preferred alternative but was not selected because it does not meet the purpose and need as aeffectively as other alternatives.

For all other information about this project and the alternatives, refer to the Final EIS for the Bozeman Municipal Watershed published in March 2010. A separate summary document accompanies the SFEIS and is available for review.

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Background

Document Structure

The Forest Service has prepared this supplemental final environmental impact statement in compliance with the National Environmental Policy Act (NEPA) and other relevant Federal and State laws and regulations. This environmental impact statement replaces and/or supplements the disclosure in the Final EIS for the direct, indirect, and cumulative environmental impacts that would result from the proposed action and alternatives specific to big game/elk, fisheries, sensitive plants, soils and water quality. The document includes the following information:

- *Background Information:* This section presents reviews basic information about the Project.
- *Supplemental Affected Environment and Environmental Consequences*: This section describes the environmental effects of implementing the proposed action and other alternatives. This analysis is organized by topic.
- *Consultation and Coordination:* This section provides a list of preparers and agencies consulted during the development of this supplemental environmental impact statement.
- *Appendices:* The appendices provide a listing of soil and water best management practices.
- *Index:* The index provides page numbers by document topic.

Additional documentation, including more detailed analyses of project-area resources, may be found in the project planning record located at Bozeman Ranger District.

Background

Changes between Final and Supplemental EIS

This section adds a brief explanation of the activities that led to the need for a supplemental analysis and the work done since the March 2010 Decision was made.

On March 11, 2005, the Forest Service and the City of Bozeman signed a Memorandum of Understanding to “establish a framework for cooperation between the parties to maintain (in the long term) a high-quality, predictable water supply for Bozeman through cooperative efforts in part by implementing sustainable land management practices.” This memorandum was a culmination of three different assessments of the Bozeman Municipal Watershed including a Forest Service risk assessment (Bozeman Creek Prototype Analysis, Gallatin National Forest, 2003), a Bozeman Creek watershed assessment by the Bozeman Creek Watershed Council (Sourdough Creek Watershed Assessment, 2004), and a City of Bozeman Source Water Protection Plan (City of Bozeman, 2004). All three of these assessments concluded that fuel conditions within the Municipal watershed posed risks to the municipal water supply in the event of a wildfire.

Bozeman and Hyalite Creeks are the primary sources of water supply for the City of Bozeman. The City has water intake diversions on both streams near the Forest boundary with pipelines to the City Water Treatment Plant near the Bozeman Creek trailhead. Approximately 80% of the City's municipal water supply originates from these drainages with an additional minor source in Lyman Creek in the Bridger Mountains. Water quality in both Bozeman and Hyalite Creeks is very good and in compliance with water quality standards. The Montana DEQ water quality standards for both drainages are very restrictive. Bozeman Creek is designated as A-Closed and Hyalite Creek as A-1. These are non-degradation classifications with very strict controls on turbidity and non-point sources.

The Hyalite Creek and Bozeman Creek drainages have been designated as wildland urban interface (WUI) by Community Wildfire Protection Plan (Gallatin County, 2008). It identifies the project area as being within the designated protection plan area. There are several homes and sub-divisions in this WUI area. Many of the homes are within one half mile from the forest boundary.

Because of the importance of the municipal watersheds and their proximity to the urban interface, the Gallatin National Forest proposed to mitigate the potential effects of wildfire in the watershed and WUI by using thinning and prescribed fire to reduce fuel loadings that had accumulated over the years. This proposal became known as the Bozeman Municipal Watershed Fuels Reduction Project. The Gallatin National Forest first asked for public comments on the proposed project in September of 2005.

A Final Environmental Impact Statement (FEIS) and Record of Decision for this project were published in March 2010. The decision was appealed to the Regional Appeal Deciding Officer in Missoula, MT. In the review of these appeals (2), the Deputy Regional Forester agreed that it was not clear how the analysis was consistent with the Regional Soil Quality Standards; consequently, the decision was remanded to the Forest.

Since this time the Forest interdisciplinary team has taken the opportunity to spend additional time in the field to collect additional soils information and validate conclusions from the FEIS. Many of the questions brought up in the appeals were field checked, considered for further analysis and discussed with other agencies such as Montana DEQ. Literature citations from the appeals were reviewed and, where applicable, added to the discussion in the resource analyses. The compilation of these reviews and additional analyses make up the Supplemental Final Environmental Impact Statement (SFEIS). Where no changes or additions were made, the original FEIS stands as the complete analysis document. Where changes or additions would clarify or further the analysis, sections from the FEIS are replaced, in total, in the SFEIS.

This period of time also allowed for additional field data to be collected that could validate or invalidate the assumptions and modeling documented in the FEIS. The prescriptions for the vegetation treatments were refined and finalized and many of the treatment areas were laid out or refined on the ground. This was valuable information that usually is not available until final implementation, after a decision is made. The Forest Service found nothing in this additional data that was contrary to the analysis and conclusions made in the FEIS or that would lead the decision maker to think that the alternatives or decision are not well founded.

During this time period from March 2010 to January 2011 several new pieces of information came to light for us to consider. One of these was the information presented in the administrative appeals. The team considered any new information presented there and checked the original analysis to ensure that any issues raised were addressed and documented in the project record. Also during this time four projects came to light that could be considered in the cumulative effects for some resources. These projects include improvements to the trailhead adjacent to the Forest boundary in Bozeman Creek; the City of Bozeman forest management plan for their lands in Bozeman Creek; an initial proposal from the Montana Department of Natural Resources and Conservation to implement vegetation treatment on their lands outside the Forest boundary to the north and east of the BMW project area; and last, a water impoundment facility or dam feasibility study in Sourdough Creek. The study for a water impoundment facility was a feasibility study. The city of Bozeman has not presented the Forest Service with a proposal or request of any kind to pursue a water impoundment facility so the project was determined to be speculative and not reasonably foreseeable. The cumulative effects analysis is included in the record and was considered in the analysis by resource specialists.

Finally, over the course of these months, a few court cases were decided that may have implications or precedent setting findings for the BMW project. These include direction on species viability, a ninth circuit decision on the Smith Creek Fuels Reduction project concerning big game habitat components and an Oregon case (Northwest Environmental Defense Center v. Brown) concerning the use of a Clean Water Act exemption for forest roads. The reader will find a discussion of these findings in the SFEIS. It is important that we consider all of the current information available at the time of this decision.

See Figure 1, Vicinity Map for the general location of the project.

Decision Framework

Changes between Final and Supplemental FEIS

There are no changes to this section except to acknowledge that the supplemental analysis will be considered in the decision.

This Supplemental Final EIS is not a decision document; it does not identify the alternative to be selected by the Deciding Official. This document discloses the environmental effects of implementing the proposed action and the alternatives to that action. The Gallatin Forest Supervisor, Mary Erickson, is the Deciding Official. Based on the analysis documented in this SFEIS, the FEIS (2010) and comments received on the DEIS (2007), she will make a decision on the project. Her decision and rationale for that decision will be documented in the Record of Decision.

The Forest Service has signed a Memorandum of Understanding with the City of Bozeman to "establish a framework for cooperation between the parties to maintain (in the long term) a high-quality, predictable water supply for Bozeman through cooperative efforts in implementing sustainable land management practices".

Decisions made for National Forest System lands are separate from those made by the City. Land management decisions on Federal lands within the watershed are made solely by the Forest Service. Decisions on City lands within the watershed and decisions about City water treatment and storage facilities remain outside the scope of any Forest Service decision although the cumulative impacts of any treatments on City lands in Bozeman Creek are analyzed in Chapter 3 and would be considered in the decision. Given the purpose and need, the deciding official reviews the proposed action, the other alternatives, and the environmental consequences identified in the Final EIS and the Supplemental Final EIS in order to make the following decisions:

The decisions to be made are:

- The kinds of fuel treatments that would best help to reduce the severity and extent of potential wildfire in the lower reaches of the municipal watershed by modifying fire behavior. This includes harvest and post-harvest treatment of fuels.
- The amount and location of the treatments to be most effective in reducing the severity and extent of potential wildfire.
- Location of temporary road construction and standards for rehabilitation of roads and skid trails.
- The short term risk and tradeoff to resources such as water quality and visuals that these activities would cause weighed against the long term risk of severe wildfire.
- Whether a project specific amendment for visual quality standards for certain units of land is appropriate.

Public Involvement

Changes between Final and Supplemental EIS

This section discloses the public involvement since the FEIS.

All public involvement activities up to the release of the Final EIS were discussed in the FEIS. The Notice of Availability for the FEIS and Record of Decision was in the Federal Register on March 22, 2010. A legal notice was posted in the Bozeman Daily Chronicle on March 26, 2010. In May 2010 the Decision was appealed.

The interdisciplinary team (ID) team used the information presented in both administrative appeals to validate their analysis and findings and as a chance to ensure that they had considered any new, previously undisclosed scientific information or arguments. The informal appeal resolution meeting allowed the interdisciplinary team to better understand the issues of the appellants. The wildlife biologist involved one of the appellants in a review of the wildlife field work and analysis methods to determine big game hiding cover. The decision maker had a conversation with Michael Garrity (the other appellant) after the decision was remanded, again to better understand the issues that he raised during the appeal period. These were all helpful conversations that contributed to the entire process of involving and listening to the public.

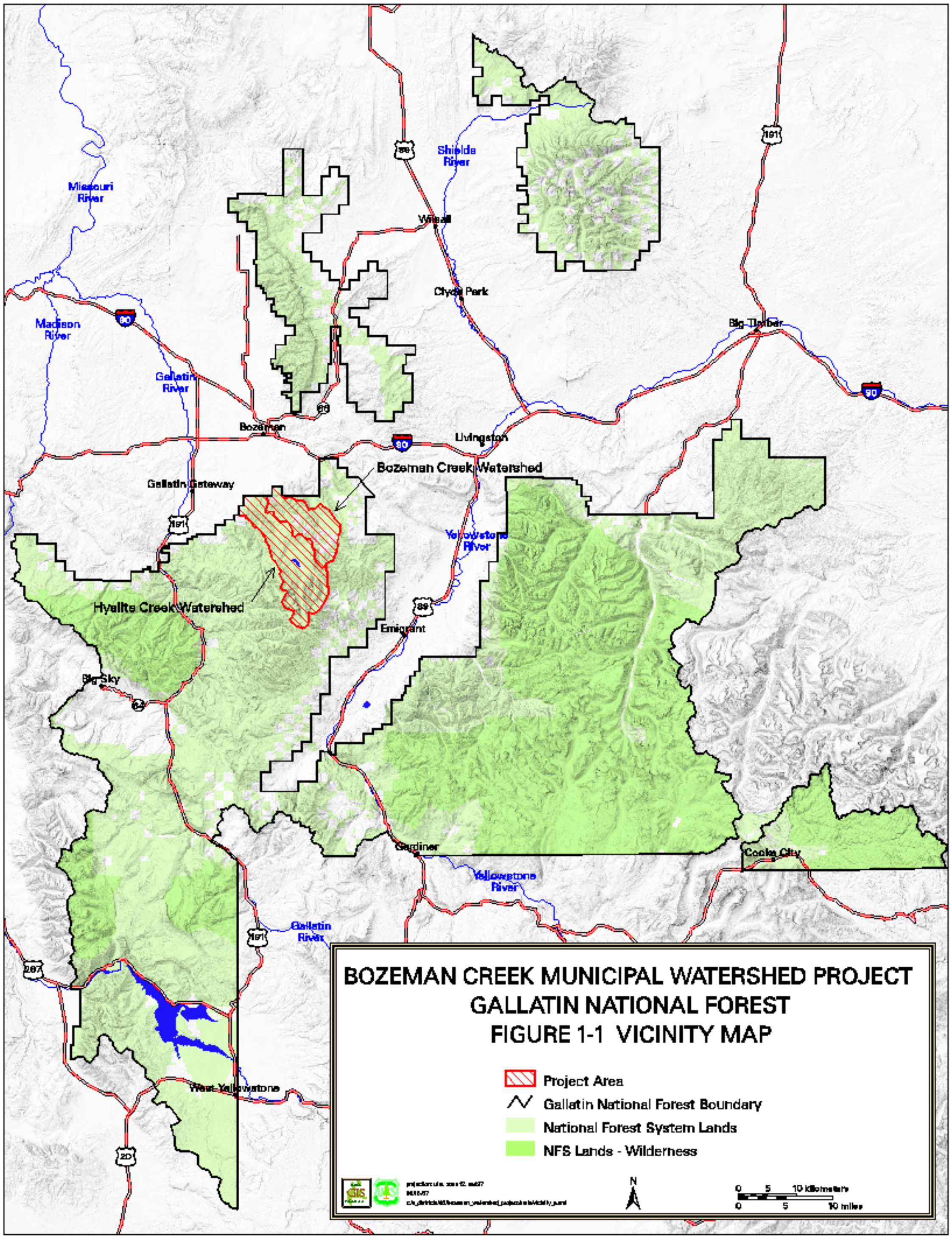
The team had the opportunity to spend time between June 2010 and now to talk further with the public about the project and to hear additional feedback about the proposed project. The Bozeman Ranger District staff took many members of the public to the field to visit the treatment areas and the initial layout on the ground. Some of those who participated were the local fire department staff and a board member, a conservation associate with the Greater Yellowstone Coalition, the City of Bozeman's contract forester and staff engineer, an appellant representing the Native Ecosystem Council and partners from Montana DEQ. These tours were tremendously valuable as a way to validate or question the work we were proposing and to share implementation level information about the project with the public at a point in time that usually comes far after a decision is finalized.

Several of our partner agencies also weighed in with letters of support for the project and the objectives to be met. The State Forester, Bob Harrington, representing the Montana Department of Natural Resources and Conservation, sent a letter to the Forest expressing his “complete support for the selected alternative”. Mark Boston, Bureau Chief for Water Quality at Montana Department of Environmental Quality (DEQ), sent a letter affirming the Bozeman Municipal Watershed (BMW) project water quality best management practices (BMP) and concluded that the project is consistent with Montana water quality regulations. The Forest also received a letter of support for the project and its purpose and need from the US Environmental Protection Agency. The district ranger and staff shared information and had additional discussions with the Bozeman City Commission, the Board of the Sourdough Fire Department, an adjacent homeowners group in Hyalite Creek, other local land owners and user groups. The Bozeman Chronicle also published a supportive guest editorial on the project.

Although additional information and data is presented in the Supplemental FEIS, the conclusions reached and compliance determinations did not change and no new alternatives were considered. The analysis disclosed a reduction in potential impacts to resources based on supplemental analysis. The decision maker found nothing in this additional data that was contrary to the analysis and conclusions made in the FEIS or that would lead the Agency to think that the alternatives or decision are not well founded. For these reasons a supplemental final EIS was prepared rather than a draft supplemental EIS. In 40 CFR 1502.9, the agency is directed to prepare Environmental Impact Statements in two stages and then they may be supplemented. One of the reasons a supplement can be prepared is to further the purpose of the act [NEPA] to consider and disclose the effects of the federal actions: the line officer determined that publication of a SFEIS would inform the public of the supplemental analysis and findings that affirm the conclusions in the FEIS.

A Notice of Availability (NOA) of the Supplemental FEIS will be published in the Federal Register. A legal notice announcing the SFEIS and ROD will also be published in the Bozeman Daily Chronicle, which is the newspaper of record, for the Gallatin National Forest. The legal notice of the Record of Decision in the Bozeman Daily Chronicale will initiate an administratvice appeal period.

Figure 1. Vicinity Map.



Issues

Changes between Final and Supplemental EIS

This section describes the issues addressed in the Supplemental FEIS.

The supplement is focused on the issues identified during the administrative appeal process that warranted additional analysis or issues in which recent court rulings from past litigation resulted in the need for further analysis. The Forest Service identified the following issues to be addressed in the supplemental final environmental impact statement:

Elk and Other Big Game: Fuel reduction treatments such as mechanical thinning and prescribed burning can alter big game habitat by reducing security cover, affecting quantity and quality of forage production, and consequently influencing the juxtaposition of cover and forage within a project analysis area. Habitat alterations associated with fuel reduction projects could influence predator-prey relationships through various mechanisms, including hunter access. Increased human presence and noise associated with proposed actions can cause disturbance and/or displacement of big game animals. Combined effects of habitat alterations and disturbance factors could ultimately affect big game distribution patterns within and near the project analysis area.

Fisheries and Other Aquatic Species: Fuel reduction activities, including harvesting, thinning, prescribed burning and associated activities, may disturb soils and overland flow regimes, which, in turn increases the potential for erosion and sediment transport to streams and other water bodies. Increased fine sediment in streams and other water bodies can reduce habitat quality and cause adverse effects to fish and other aquatic biota.

Sensitive Plants: The FEIS mistakenly reported that sensitive plant surveys had not been conducted in the project area. Sensitive plant surveys were completed for proposed treatment units in 2008 (surveys documented in project record). No sensitive plants were found. This section replaces the discussion in the FEIS.

Soils: Proposed fuel treatments in the Bozeman Municipal Watershed Fuels project could potentially cause long term impairment of land productivity and reduced soil quality within treatment units if inadequately planned or implemented. Of specific interest is the level of detrimental soil disturbance created in tractor harvest and mechanical thinning areas as well as the potential for increasing unauthorized, off road vehicle use in portions of the area.

Water Quality: The BMW project is designed to help protect the City of Bozeman's municipal water supply. The issue is the long term tradeoff of risking potentially severe wildfire and associated high sediment increase risk compared to the activities of this proposal and possible short term increases in sediment to the City of Bozeman water treatment plant. Proposed fuel treatments along with the cumulative effects of existing roads, new temporary roads, and recreation could have an adverse effect on water quality by introducing additional sediment to Hyalite Creek, Bozeman Creek, and Leverich Creek. Increased nutrients in streams may occur from prescribed burns. Increased sediment delivery could have adverse effects on stream channel conditions, water quality, aquatic habitat, and/or downstream beneficial uses.

Other Related Efforts

Changes between Final and Supplemental EIS

This section incorporates cumulative effects consideration from recently disclosed activity on adjacent lands.

Since the Final Environmental Impact Statement was released in March 2010, four projects have been discussed in the vicinity of the project. Three of these projects are reasonably foreseeable. The interdisciplinary team considered potential cumulative impacts associated with these activities and determined that there would be no notable change to the cumulative effects analysis. These activities do not result in additive impacts that altered conclusions or compliance with existing standards and regulation. (SFEIS Cumulative effects checklists 2010) The following activities are proposed on nearby lands.

Montana Department of Natural Resource Conservation - DNRC is considering harvest activities including road construction and reconstruction in an area encompassing up to 1,300 acres within sections 1, 2, 3 and 4 in T3S., R6E and sections 34 and 35 in T2S, R6E near the Bozeman Municipal Watershed Project. The lodgepole pine trees in the area are experiencing mountain pine beetle mortality and Douglas-fir stands within the area are confronted with health and vigor issues and would benefit from selective harvest practices. A decision is scheduled for spring 2011. For a map of the area go to http://dnrc.mt.gov/trust/timber/information/BearCanyon/default.asp the activity is outside the municipal watershed and outside the cumulative effects analysis boundary for most national forest resources. Where there is potential for additive impacts they were determined to be minor. In the case of meeting the purpose and need for this project related to the wildland urban interface, there would be a potential benefit.

Trail head improvements were implemented. The Sourdough trailhead is in Section 7, T3S, R6E (private land) near NFS lands. In 2010 the Gallatin Valley Land Trust installed a permanent vault toilet and expanded parking slightly to the east. When funding is available some road work, stream restoration and irrigation ditch work is proposed. The potential impacts from this activity were minor and there would be no significant cumulative effects to NFS resources.

Fuel reduction Activities are proposed on City of Bozeman lands within the Bozeman Creek drainage. The proposal is intended to reduce the risk of wildfire impacts that would deposit large amounts of sediment in Sourdough Creek. This activity was discussed in the FEIS but more detail is available at this time. Immediately adjacent to the City water intake in sections 7, 17 and 18, T3S, R6E, 380 acres of harvest is proposed including about 20 acres of ground based harvest and 360 acres of helicopter harvest. The prescription identifies removal of 30-40% of the trees in most stands, with plans for leaving groups or clumps in lodgepole pine, thinning or mimicking natural openings in the Douglas fir stands. About 4500 feet (.85 miles) of road may be constructed to support logging and 4.3 miles of road reconstruction with drainage improvements. The location of these roads is not finalized and would be dependent on permission from private landowners. For these reasons, the proposed road related impacts are uncertain. Further up the road in section 27, T3S, R6E. In stands immediately adjacent to the road, approximately 260 acres of thinning or group/clump removal is proposed. Approximately 30-50% of the stands would be removed depending on the forest types. No additional roads are proposed. Although the Forest Management Plan

(Peck 2009) includes more harvest, the City is only planning to implement harvest in the previously described sections in the reasonably foreseeable future. The city has limited funds to commit to the Plan and the sections near the intake are the top priority for management (Heaston, personal communication 2010). The additional detail provided did not result in any notable change to potential cumulative impacts since the interdisciplinary team considered the city's plan to treat City lands throughout the NEPA process.

Sourdough Dam Proposal: The City of Bozeman retained a consultant to prepare a study of future water needs and availability for long term water use planning. One part of the study included developing a proposal for surface water storage to replace storage lost when the Mystic Lake Dam was breached in 1984-85. Surface water and ground water alternatives were developed. The City is investigating options along Sourdough Creek for water storage. The Study concluded that no fatal flaws exist to prevent the construction of the reservoirs and two ground water sources could be developed for water supply. Although the Study is of interest to many people the proposal is not reasonably foreseeable. The document was a feasibility study. The Forest Service has not received any notice or application for a water impoundment in the Bozeman Creek drainage. In the event a proposal is presented by the City, a full environmental analysis would be conducted in which potential cumulative effects would be considered.

Supplemental Affected Environment and Environmental Consequences

Issue: Elk and Other Big Game

Changes between Final and Supplemental EIS

This section replaces Issue#20 – Elk and Other Big Game Species section of the FEIS. (p. 3-401 to 415) In response to public comment, appeal issues and recent litigation on similar projects, mapping and assessment of hiding cover were further evaluated in order to demonstrate compliance with Forest Plan standards. The habitat assessment in the FEIS was based on a conservative estimate of hiding cover to account for the availability of forage in some of the more open forest structure types (which are also capable of concealing a standing adult elk). This assessment focused on evaluating forage:cover ratios, relative to Forest-wide standard 6.a.3 (p. II-18). However, it was determined that the forage:cover ratio assessment under-represented the amount of hiding cover in the project analysis area with respect to Forest-wide standard 6.a.5 (p. II-18) to maintain hiding cover over time. Stand examinations and additional field data collection helped validate the model used to assess hiding cover for the project (USDA 2010a). The revised analysis in the Supplemental FEIS recognizes that some forested habitat provides hiding cover as well as foraging opportunities for big game species.

Introduction and Statement of Issue

Elk (Cervus elaphus), moose (Alces alces) and deer (Odocoileus spp.) are highly sought-after big game species that occur in the project analysis area. The Forest Plan has designated elk as a Management Indicator Species (MIS) for big game habitat (USDA 1987: II-19) under the premise that by managing for productive elk habitat, we will be managing for most big game ungulate species. Big game hunting and wildlife watching are integral to western culture, major contributors to local economies, and account for a majority of recreation user days on National Forest System lands. Therefore, there is significant public interest in projects that have the potential to affect big game and their habitat.

Issue

Fuel reduction treatments such as mechanical thinning and prescribed burning can alter big game habitat by reducing hiding cover, affecting quantity and quality of forage production, and consequently influencing the juxtaposition of cover and forage within a project analysis area. Habitat alterations associated with fuel reduction projects could influence predator-prey relationships through various mechanisms, including hunter access. Increased human presence and noise associated with proposed actions can cause disturbance and/or displacement of big game animals. Combined effects of habitat alterations and disturbance factors could ultimately affect big game distribution patterns within and near the project analysis area.

Indicator

Effects to big game were addressed by evaluating project impacts to cover, forage and other key habitat component availability and distribution throughout the project analysis area. Disturbance effects were assessed by considering the timing and duration of disturbance factors. Amount and distribution of secure habitat were evaluated relative to big game vulnerability. Road and motorized access route densities were considered with respect to disturbance factors as well as vulnerability.

Summary

The project analysis area provides fall, winter and spring range for elk, but better quality summer range is typically found at higher elevations surrounding the project analysis area. Moose and mule deer (O. hemionus) can be found in the project analysis area year-round, although some individuals spend summer at higher elevations, and/or winter at lower elevations. Whitetail deer (O. virginianus) will occasionally enter the project analysis area, but are more commonly found on adjacent private lands and agricultural fields. Big game animals show a preference for moist sites during summer months. These sites are selected based on juxtaposition with other habitat components such as forest cover. Moist habitat types are rare in the project analysis area, representing less than 3% of the total area. Forest cover provides a measure of security for reducing risk from predation, temperature extremes and other environmental factors. Cover includes a variety of habitat components for big game, such as hiding cover, thermal cover, escape cover and overall security. Cover is not limiting in the project analysis area, with approximately 90% of the landscape dominated by forested habitat at various stages of succession that provide thermal or hiding cover, or both.

Alternative 1 would have no direct habitat alteration or disturbance impacts on big game. However, the No Action alternative would not improve forage conditions for big game, and continued fuel buildup could contribute to a large scale fire event, which could result in much greater reductions in forest cover than any of the action Alternatives. Alternative 2 would have the least reduction of hiding cover, including cover along forested ridgelines that provide important travel routes for big game among the action alternatives. Conversely, Alternative 2 would have the least amount of potential forage improvement among the action alternatives. Temporary project road construction and use, coupled with noise from heavy equipment used for commercial timber harvest in Alternatives 2, 3, 5 and 6 would have greater disturbance impacts to big game than would occur under Alternative 4. Alternative 4 would have no negative impacts associated with road construction or use, but could have disturbance impacts in secure habitat, and would also impact cover along ridgeline travel corridors. Alternatives 3, 5 and 6 could result in considerable increases in foraging habitat, but at the expense of reductions in hiding cover, additional temporary road construction and potential for ongoing project activities to displace big game from suitable habitat. With the addition of ridgeline fuelbreaks, Alternative 6 could have a greater impact on big game movement and distribution than other alternatives. Of all the alternatives, including no action, Alternative 4 would likely have the most potential to benefit big game species by increasing forage amount and quality relative to cover availability, with the fewest disturbance impacts among the action alternatives.

All alternatives would meet Forest Plan and other pertinent direction to provide habitat for big game.

Background

Affected Environment

The project analysis area provides fall, winter and spring range for elk, but better quality summer range is typically found at higher elevations surrounding the project analysis area. Moose and mule deer (O. hemionus) can be found in the project analysis area year-round, although some individuals spend summer at higher elevations, and/or winter at lower elevations. Whitetail deer (O. virginianus) will occasionally enter the project analysis area, but are more commonly found on adjacent private lands and agricultural fields. Elk are primarily grazers, consuming grasses and forbs for most of their diet, but using browse species as well, mainly in winter. Moose are browsers, using the twigs, buds, stems and even bark of woody plants, although they will use aquatic vegetation where readily available. Deer are more general in their foraging strategy; i.e. neither strongly grazers nor browsers, but tend to be more selective about the individual plants they eat. Hoffman (1985 cited in Mackie et al. 2003:893) described deer as "concentrate selectors", which due to a relatively small rumen, must consume smaller quantities of higher quality, easily digestible plant materials, as compared to the larger ruminants, or "bulk feeders" that can eat larger quantities of lower quality forage.

Generally speaking, elk feed primarily on grasses in spring, with forbs becoming more important in summer. They switch back to grasses and start to include browse species by fall and into winter (Peek 2003:881). Elk winter range in the project analysis area is characterized by warmer, drier slopes of southerly aspect, that remain relatively free of snow, contain open areas of grass and shrub cover, with coniferous forest nearby to provide thermal and hiding cover. The project analysis area does not contain large areas of elk winter range that can support herds of elk like other places in the Gallatin Range. Most of the elk winter range in the project analysis area is located on south-facing slopes on the east side of the Bozeman Creek drainage. Spring range for elk typically occurs in the transition zone between winter and summer range. Calving areas, which are part of spring range, occur at the upper elevational limits of winter range, where shrubs and conifers provide hiding cover to help protect calves from predation. Johnson (1951 cited in Peek 2003:882) reported elk calving grounds in the Gallatin Range as interspersed sagebrush and timber, where newborn calves in sagebrush were found within 70 m (230 ft) of timber, and calves found in timber were within 9 m (30 ft) of sagebrush. Sage is a relatively minor component in the project analysis area, found mainly in association with winter range. Fall habitat for elk in the project analysis area is generally represented by forested habitat that provides hiding cover as elk make their way to wintering areas.

Mule deer can be found within the project analysis area year round, although mature bucks tend to spend summer months at higher elevations outside the project analysis area, while females and yearlings tend to winter more outside the project analysis area. Winter range for mule deer is similar to that described above for elk. A few individuals, mainly mature bucks, can be found wintering within the project analysis area. Larger groups of does and yearlings typically winter in valley bottomlands, usually on private and agricultural land outside the project analysis area. However, these maternal groups will often stay close to forested habitat for security, and may venture into the project analysis area during particularly harsh weather. Reproductive habitat for mule deer is that used by does during fawning and lactation. Mackie et al. (1998:25-26) described reproductive habitat in mountain-foothill environs as mesic montane forest, with a wide range of topographic and vegetative diversity, to provide a dependable source of succulent, high-quality forage, as well as escape terrain to avoid predators. Moderately steep slopes with northerly exposures provide good quality reproductive habitat for mule deer in the project analysis area.

Moose occur at low densities throughout the project analysis area year round. They are typically found in association with willow/riparian and upland shrub habitat, although there is ample evidence of moose presence in mature forested types as well. Moose tend to show a strong degree of sexual segregation outside the breeding season, with males typically selecting habitats relative to forage availability and females selecting habitat for security cover (Bowyer et al. 2003:944). Browse is the primary foraging technique, with twigs and stems of woody plants making up the bulk of their winter diet, while leaves and tender young shoots of trees and shrubs are used the rest of the year (Ibid. 2003:940). Stevens (1970) reported on winter ecology of moose in the Gallatin Range. He noted that moose along the north slope of the Gallatin Range (which includes the BMW project analysis area) tend to concentrate at lower elevations (at or below 6,000 ft) in late winter. This study identified willow (Salix spp), Douglas fir (Pseudotsuga menziesii) and chokecherry (Prunus virginiana) as the most important winter browse species for moose in montane forest types, although huckleberry (Vaccinium spp) and alder (Alnus spp) were used as well.

Weixelman et al. (1998 cited in Bowyer et al. 2003:941) found moose foraging selection to be influenced by distance to cover, with altered diet selection and feeding on less preferred species evident at greater distances from cover. Molvar and Bowyer (1994 cited in Bowyer et al. 2003:941) also reported that moose foraged less efficiently; e.g. took larger, less nutritious bites, the further they were from security cover. These authors found that cow moose with calves were particularly sensitive to predation risk, and altered their foraging patterns relative to proximity of security cover. Calving areas for moose are not based on broad-scale habitat characteristics like other cervid species, but rather female moose select isolated areas based on microsite characteristics such as food availability and view for detecting potential predators (Bowyer et al. 2003:944).

Studies in Montana indicate that elk show a preference for moist sites during summer months. These sites are selected based on juxtaposition with other habitat components such as forest cover, and are generally associated with forest habitat types in the subalpine fir (Abies lasiocarpa) and spruce (Picea spp.) series (Lyon et al. 1985:12). The majority of elk summer range is located at higher elevations, outside the project analysis area. Spruce and moist subalpine fir habitat types represent only a small proportion (less than three percent) of the project analysis area, largely due to the project location at relatively low elevation. However, some moist sites occur in the project analysis area, and they provide important habitat for big game by supplying water, high quality forage, wallows and other benefits. These features are often quite small (sometimes only a few feet in diameter) and can be difficult to identify and map on a project basis. Moist sites in the BMW project analysis area are generally associated with stream corridors, seeps or springs. The majority of wetland types in Hyalite and Bozeman Creek drainages occur at elevations above the project analysis area. Within the project analysis area, moist types are generally not located within proposed treatment units, see Figures 2 and 11.

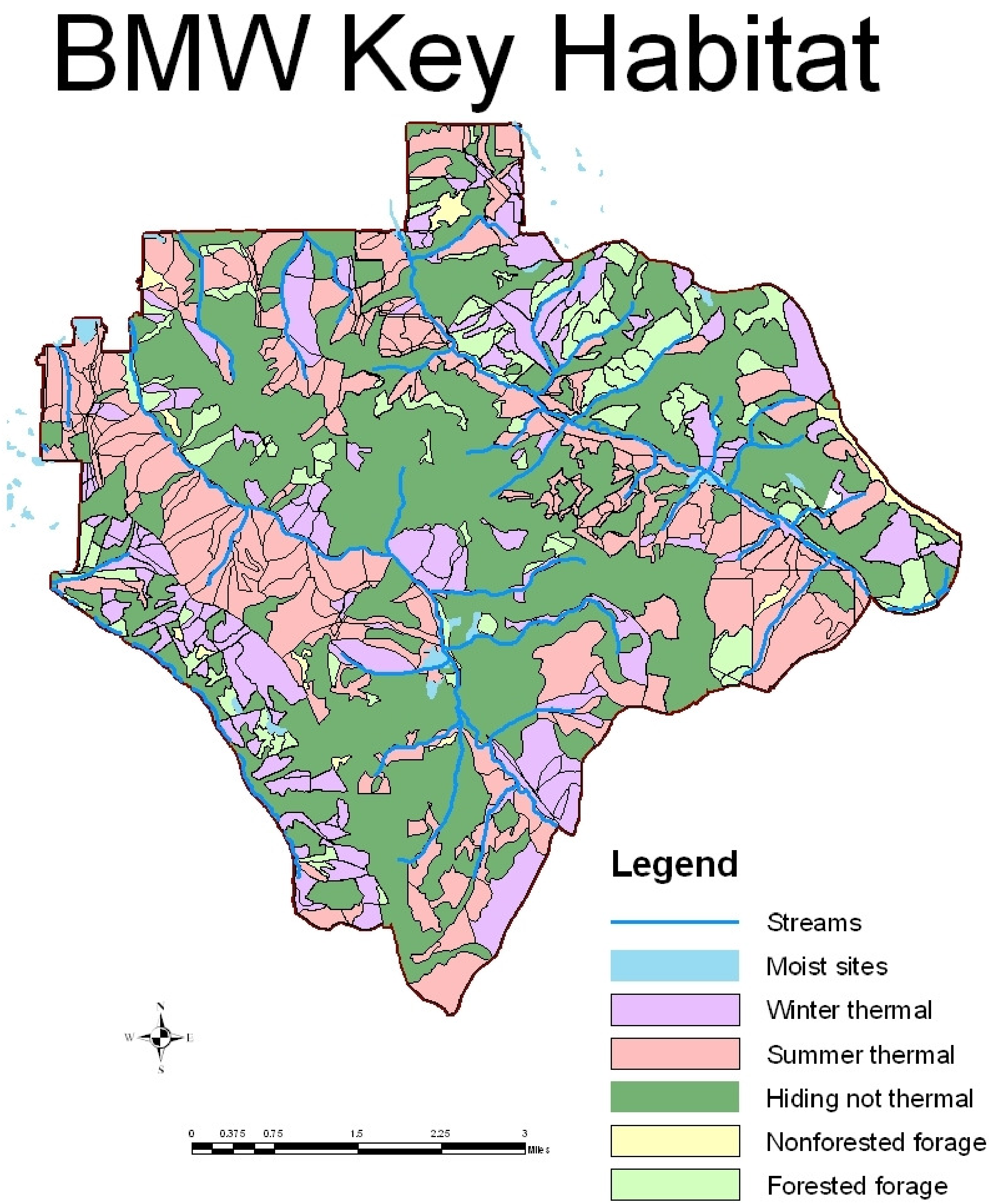
Forest cover provides a measure of security for reducing risk from predation, temperature extremes and other environmental factors. Cover is a term with broad interpretation and which includes a variety of habitat components for big game, such as hiding cover, thermal cover, escape cover and overall security. In the Gallatin Forest Plan (Amendment No. 14, Big Game Cover Definitions), hiding cover is defined as vegetation capable of concealing 90% of a standing adult big game animal from the view of a human at a distance equal to or less than 200 feet. Thermal cover is a habitat security component that provides structure necessary to ameliorate effects of ambient temperature on big game species, thus reducing the amount of energy expenditure required for thermoregulation. Thermal cover requirements vary by season, with warmer, drier aspects typically selected for winter thermal needs, and cooler, moister types serving as summer thermal cover. The Forest Plan (Amendment No. 14) defines thermal cover as mature conifer stands (tree height of at least 40 feet) with a canopy cover of at least 70%. Thermal cover generally provides hiding cover as well, but since thermal cover also has slope and aspect requirements it is considered more limiting. For analysis purposes, thermal cover was identified first, and all other habitat that met cover criteria was considered to be hiding cover.

Cover is not limiting in the project analysis area, with approximately 90% of the landscape dominated by forested habitat at various stages of succession that provide thermal or hiding cover, or both. Timber harvest has occurred in the project analysis area in the past, but most harvest units have since regenerated to a condition where they now provide hiding cover for big game. Within the project analysis area, approximately 20,324 acres (about 91% of the entire project analysis area) are considered capable of producing hiding cover. Currently, only about 184 acres of "capable" habitat have been burned or harvested in the past and have not yet recovered to a point where they can provide adequate hiding cover for big game. Approximately 49% of the existing hiding cover in the project analysis area meets the definition of thermal cover as well. While there is some forage available under forest canopies, the amount and quality of such forage can be limited by reduced exposure to sunlight, competition for water and nutrients from conifers, and unfavorable soil conditions resulting from high concentrations of conifer needles. More open forest canopy generally produces more favorable forage conditions.

The BMW project analysis area provides habitat for big game during transitional periods such as seasonal migrations. Migration typically occurs as elevational movements between summer and winter ranges, but some lateral movement across slopes occurs as well. Big game migration is primarily influenced by weather patterns and associated factors such as temperature and snowpack. There are no definitive migration routes known to exist within the project analysis area; rather, travel occurs in a dispersed pattern throughout the area (K. Alt, pers. comm. 2009). Likewise, there are no known identifiable staging areas used by big game in the project analysis area. Instead, individuals and small groups of animals select and use staging areas as opportunities present (Ibid). Increasing numbers and distribution of predators in the Greater Yellowstone Ecosystem are potentially affecting the ability of big game herds to use traditional travel routes, or to congregate and remain (i.e. stage) in one area for any length of time.

Proposed treatments are focused in an area of the Gallatin Forest where existing open road densities and total motorized access route densities tend to be higher than many other areas of the Forest. This condition is attributed to a number of factors including proximity to the population center of Bozeman and adjacency to private lands, high recreation demands, and administrative needs to manage lands for developed recreation, municipal water supplies and other resources. High levels of motorized use can have disturbance and displacement effects on big game species. The current open road density in the BMW project analysis area is 1.28 mi/mi^2. Considering the additional motorized use on trails brings the current total motorized access route density in the project analysis area to 1.36 mi/mi^2.

Figure 2: Key habitat components map for the analysis area.



Applicable Laws, Regulations, Policy and Forest Plan Direction

Elk, moose and deer are all species native to this area, and as such, the Forest Service has a responsibility under the National Forest Management Act (36 CFR 219.19) to provide habitat for them. The Gallatin Forest Plan contains a goal to provide habitat for all indigenous wildlife species including increasing populations of big game animals (p. II-1). Forest-wide standards in the Forest Plan require that winter range be managed to meet the forage and cover needs of deer, elk, moose and other big game species in coordination with other uses, and that at least two thirds of the hiding cover associated with key habitat components be maintained over time (p.II-18). Key habitat components include moist areas (wallows, etc), foraging areas (meadows and parks), thermal and hiding cover, migration routes and staging areas. These features have been mapped for the project analysis area to the extent that locations on the landscape are known, or can be modeled with existing data, see Figure 2 and Figure 11, which is the wetlands map. The Forest Plan also contains a standard that Management Indicator Species (in this case, elk) will be monitored to determine population change (Ibid). Since this is a forest-wide standard, population trends for MIS are monitored at the Planning Unit level; i.e. the Gallatin National Forest. Currently population trends for elk across the Gallatin Forest are stable to increasing (USDA 2011b).

Forest Plan standards relevant to big game for the Management Areas (MA) in which fuel reduction treatments are proposed tend to be more general and include the following. Habitat improvement projects consistent with MA goals may be scheduled (MA 5, 8, and 9). Maintain suitable habitats for those species of birds, mammals and fish that are totally or partially dependent upon riparian areas for their existence (MA 7). Project plans will incorporate Forest-wide standards for wildlife (MA 8). Schedule vegetation management practices such as prescribed fire to maintain or improve the quality and quantity of wildlife habitat (MA 12). Coordinate habitat improvement projects between livestock and big game needs (MA 17). The Gallatin Forest Travel Management Plan contains direction that project roads should be temporary in nature, and effectively gated to restrict public motorized use. Once the activity is complete, project roads should be permanently and effectively closed and re-vegetated (Guideline D-7, Ch. I-II).

Methodology for Analysis

Field site visits were made to the project analysis area between 2004-2010 to collect data and evaluate existing conditions. During these visits, presence of big game species was verified based on sightings, scat and track detections. Evidence of herbivory was noted, as was obvious use of key habitat components such as wallows, etc. In proposed treatment units, ocular estimates were used to assess whether past harvest units had regenerated to a point where they now provide hiding cover. Hiding cover attributes were also field-validated using an observer and targets including a cover board and a life-sized adult elk decoy to determine whether an area contained vegetation capable of concealing a standing adult big game animal from the view of a human at distances of 200 feet or less.

GIS technology was used to assess existing habitat patterns such as cover, forage and other key habitat availability and distribution, as well as to evaluate potential impacts of proposed actions on big game habitat. We modeled big game habitat using vegetation data maintained in the Timber Stand Management Record System (TSMRS) for the project analysis area. TSMRS contains attributes for stands, or landscape polygons, delineated from aerial photo interpretation, (or "PI typing"). Some of the data in TSMRS are field validated, but only a sample of stands get visited, and stand examinations occur across the forest in various locations over time. PI typing alone can produce good information for vegetative attributes such as dominant vegetation type (e.g. tree species, grass, forb, shrub), successional stage (relative age of forested stands), and canopy cover. However, PI typing has limited application for assessing horizontal vegetative structure under the forest canopy. Field site visits (including stand exams) provide additional information regarding vegetative structure in a forested stand, and some extrapolation was made from field data between stands with the same PI type or "best strata". Based on a review of the TSMRS data for the BMW project analysis area, as well as additional field validation and comparison with 2009 NAIP (satellite) imagery, we determined that the photo-interpreted classifications (PI best strata) were accurate for characterizing the overall functional attributes of the landscape, relative to big game. It should be noted that TSMRS data are not a 100% accurate reflection of current vegetative conditions on the ground. However, this information is sufficient to use in relative comparisons at the project level. Analyses performed with this data can provide the decision-maker with adequate information to make a reasoned decision regarding potential project impacts, including a comparative assessment of the range of potential impacts from the alternatives.

Montana Fish Wildlife and Parks personnel have produced habitat assessments in which they considered forested areas with at least 40% canopy as hiding cover for elk (Lonner and Cada 1982:6). Smith and Long (1987) developed a simulation model to predict how much of a big game animal (elk or mule deer) would be hidden in lodgepole pine stands, based on stand structural characteristics such as tree size, density and spatial distribution. We reviewed timber stand exam data available for the BMW project analysis area and found the majority of lodgepole, spruce and subalpine fir types with at least 40% canopy cover to meet or exceed the minimum stand density characteristics reported by Smith and Long (1987) for hiding 90% of an adult standing elk. Additional site visits to the project analysis area to measure hiding cover further confirmed that 40% or greater canopy cover provides a good surrogate for modeling hiding cover, since all stands sampled contained vegetation characteristics capable of concealing big game animals. Therefore, we selected TSMRS stands with attributes of at least 40% canopy cover for our model to estimate the amount and distribution of hiding cover within the project analysis area. A more detailed account of data collection and analysis methods for assessing hiding cover is contained in the project file (Dixon 2010).

The proportion of hiding cover maintained in an area was calculated by establishing a baseline of the amount of habitat within the project analysis area that would be capable of producing at least 40% canopy cover through natural succession over time. This process excluded from the baseline non-forest habitats such as open meadows, shrublands, rock and water, as well as park-like open forest areas that have persisted at less than 40% canopy cover over time. Areas with past activities (timber harvest or burning) that have not regenerated to a point where they now provide cover for big game were subtracted from the baseline to reflect the existing condition. Proposed treatment units were assumed to reduce existing hiding cover for the entire area within a treatment unit boundary, although in reality, prescriptions for treatment would likely leave some hiding cover within the units after implementation.

GIS and TSMRS data were used to model thermal cover, using our Forest Plan definition criteria of 70% or greater canopy cover and canopy tree height of at least 40 feet. Thermal cover was further evaluated for seasonal variation based on aspect, wherein north and east facing slopes were considered to provide summer thermal cover, while south and west facing slopes were modeled as winter thermal cover. Other key habitat features such as moist sites, foraging areas and wallows were mapped based on field observations and from aerial imagery where such habitat features were readily apparent. Since there are no readily identifiable migration routes or staging areas in the project analysis area (K. Alt, pers. comm. 2009), we did not map any as key habitat features for this project. GIS was used to calculate road and motorized trail densities for the project analysis area, as well as to model secure habitat using a ½ mile buffer from open roads and motorized routes, per guidelines set forth by Hillis, et al (1991:39).

A literature review was conducted to obtain range-wide habitat relationship information for elk, moose and deer. Montana Fish Wildlife and Parks (FWP) personnel were contacted for population trend information on Management Indicator Species, including elk. In 2007, elk populations were below state objectives for herds using parts of the Gallatin Range (C. Jourdonnais, pers. comm. 2007). However, in 2008 there was a slight upward trend for the Gallatin face herd, which includes those elk using the north end of the Gallatin Range where proposed fuel treatment activities are planned (Ibid 2008). In 2009, the count decreased slightly; the Gallatin face herd is still within the state's population objective, but at the low end of the desired range of 400-600 animals (J. Cunningham pers. comm. 2010).

Analysis Parameters

Spatial boundary:

Extreme individual variation in home range size is reported in the literature for big game, including seasonal variation between summer and winter habitat for migratory species. The only consistent factor regarding home range size is that males typically have larger ranges than females for all species considered in this report. Home range size can vary based on the geographic area considered, local habitat conditions, weather fluctuations, migrations patterns, sexual dimorphism, reproductive status and other factors. Home ranges reported for elk were 2,470 to 2,965 acres (Peek 2003:882), and for mule deer were from 100 to 900 acres (Mackie et al. 2003:896). Moose had the largest variation reported at 890 to 22,733 acres (Bowyer et al. 2003:941). Based on these figures, a project analysis area 22,296 acres in size, was established for evaluation of direct and indirect, as well as cumulative effects to big game for this project.

The spatial boundary was developed by combining Gallatin Forest Timber Subcompartments, because timber stands, and corresponding vegetative data are grouped by subcompartment number. Timber compartments and subcompartments are bounded by topographic and hydrologic features such as ridgelines, drainage bottoms, etc. These features delineate land areas in a way that is biologically and ecologically meaningful to big game species. A map of the analysis area (and associated list of subcompartments) is contained in the project file. The spatial boundary was established using the following factors: the subcompartments selected cover an area that is nearly big enough to encompass the largest home range reported for any of the focal species; contains all proposed treatment units; and contains seasonal habitat for big game species known to use the area;includes year-round habitat for various cohorts of all three species.

Temporal boundary:

Consideration of past management actions and natural events that have shaped big game habitat in the project analysis area is established in presentation of baseline habitat conditions for the area; i.e. the amount and distribution of forage and cover currently available, plus current road and trail configurations. Ongoing and reasonably foreseeable future actions were considered for ten to fifteen years from present, to cover the expected project duration of five to ten years, plus account for potential lingering displacement impacts where continual disturbance factors may cause big game to leave the project analysis area and not return for some time after project completion.

Effect Analysis

Direct and Indirect Effects of Alternative 1 (No Action Alternative)

Under the No Action alternative, there would be no habitat alteration due to fuel reduction activities on National Forest System lands in the project analysis area, and no associated disturbance factors that would affect big game species. Habitat conditions would be expected to remain largely the same in the short-term in the project analysis area unless altered by natural disturbance processes. Over time, natural succession processes in the absence of disturbance would maintain and potentially increase the proportion of late-successional forest types, which provide hiding cover for big game species. Thomas (1979:121) suggested the optimal mix of habitat for elk and deer is 60% forage to 40% cover. While this may be an optimal mix where there are few disturbance factors, cover may be more important in areas of high predator densities, or where human disturbance factors are a major consideration (Peek 2003:884). Security cover is not limited in the project analysis area. Increases in overhead cover would reduce the amount of forage available in forest understories. Within the project analysis area, the forage:cover ratio is currently only 16:84. Increased conifer growth (both overstory and understory) at the expense of forage production, would not benefit big game in the project analysis area.

No project roads would be constructed or reconstructed under the No Action alternative, so there would be no additional disturbance effects from construction and logging traffic on roads, nor any reduction of big game secure habitat due to the presence and use of new roads.

Cumulative Effects of Alternative 1

Continued fuel buildup in the analysis area could facilitate the rapid spread of wildfire, which could significantly reduce the proportion of late-successional forest and replace it with post-fire habitat, which generally provides better forage conditions for big game, at least in the short-term. Lyon et al. (2000:52) reported that grass and forb biomass generally increase for the first five to ten years post fire. Tyers (2003:159) cited numerous studies that showed an increase in seral shrub communities with extensive concentrations of moose forage following wildfires. Fire is an integral ecological process to which big game species have adapted in this ecosystem. While fire may benefit big game species through increased forage production, a large-scale fire event in the project analysis area could have negative consequences as well. Fast-moving wildfires can result in direct mortality of some big game animals, although most large mammals are sufficiently mobile to escape harm from wildfires (Singer and Schullery 1989 cited in Lyon et al. 2000:17). When considered in conjunction with other factors such as existing high road densities in the Hyalite drainage, recent large fires (Purdy and Fridley in 2000; Big Creek in 2006) in the project vicinity, and expanding gray wolf (Canis lupus) populations in the Gallatin Range, all of which increase the importance of security cover, a large fire event in the project analysis area and surrounding forest habitat might not be beneficial to big game species.

Effects Common to Action Alternatives (2-6)

Non-forest foraging areas, such as natural meadows and parks, are relatively rare habitat components in this area, and represent just over 1 percent of the BMW project analysis area. Open forest types provide the majority of foraging opportunities for big game in the project analysis area. Under all action alternatives, proposed fuel treatments would increase the amount of forage available for big game species. Deer and elk would benefit from increased grass, forb and shrub production, while moose would benefit primarily from increased woody shrub components. Fuel treatments could also improve habitat for big game by increasing the amount of forest-nonforest edge. Such ecotones are important to big game because they provide foraging opportunities in close proximity to hiding cover. Foraging habitat created by proposed treatment would typically be within 600 feet (three site distances) of hiding cover. Increased edge could also promote habitat diversity, which would be beneficial for most big game species in that heterogeneity provides a wider variety of forage species. However, it should be noted that conifer removal (through mechanical thinning or fire) does not always improve forage conditions. Overstory removal can cause a change in understory species composition to dominance by unpalatable plants (Lyon et al. 2000:56). Under all action alternatives, foraging habitat for big game would be increased, and at least two thirds of the hiding cover associated with foraging habitat would be maintained within the project analysis area. Since treatments involve thinning rather than clear cutting, and prescribed burns are expected to produce a mosaic pattern of live and dead trees, hiding cover would be maintained in conjunction with newly created foraging habitat.

Proposed actions would reduce available security cover in the project analysis area. Hiding cover provides protection by reducing visibility to predators as well as providing escape routes if detected by predators. Thermal cover is used by big game to ameliorate effects of ambient temperature, thus reducing the amount of energy expenditure required for thermoregulation. Moose are the primary big game occupants of the project analysis area in winter, but some elk and deer are winter residents as well. Overhead canopy reduces snow depth, which facilitates travel for wintering moose (Bowyer et al. 2003:943). Treatment units are concentrated in the lower end of the project analysis area to focus management at locations near the water treatment plant. This configuration would reduce available cover and break up the canopy in a relatively large, contiguous area. Some cover would still be retained in treatment units, but may require greater energy expenditure for effective use by big game.

Moist to wet areas are considered key habitat features in that they provide water, high quality forage and/or cover, wallows and other benefits to wildlife. All action alternatives would maintain the majority of existing forest habitat types (moist subalpine fir and spruce) that tend to produce these wet sites within the project analysis area. Alternatives 3 and 5 include the most treatment in moist forest habitat types, at approximately 120 acres each, or roughly 21% of existing moist forest habitat types in the project analysis area. Streamside Management Zone (SMZ) direction limits tree removal within a certain distance from streams, and the 15 foot no cut buffer further maintains hiding cover in these areas (Appendix A). Compliance with water quality protections would help maintain hiding cover associated with wet to moist key habitat features within the project analysis area, since many of the moist types are adjacent to or associated with stream courses; e.g. riparian vegetation.

In addition, where isolated moist to wet micro sites occur within proposed treatment units, all action alternatives contain prescriptive mitigation measures to maintain hiding cover associated with these discrete features in treatment units (FEIS p. 2-22).

Noise and increased human presence associated with proposed actions could have disturbance effects on big game, which may trigger physiological responses such as increased heart and respiratory rates that pose an energetic cost on animals. Disturbance could also cause behavioral responses such as forced escape, changes in habitat use patterns, and changes in daily use patterns (e.g. foraging at night). Behavioral responses to human disturbance could cause animals to use suboptimal habitats, resulting in increased competition, and/or increased vulnerability to predators if animals are pushed into unfamiliar areas. Disturbance factors could ultimately result in displacement of big game animals from the project analysis area. Displacement results in a reduction of useable habitat and increased stress on animals (Lyon et al. 1985:39). Continued disturbance over a relatively long duration (such as that estimated for completion of all BMW proposed actions) could cause big game avoidance of the project analysis area for an extended period of time. Lyon et al. (1985:39) reported that continued disturbance associated with follow-up procedures such as planting and/or burning following timber harvest could condition elk to avoid logged areas for a year or more after all project activity ended.

Disturbance during winter and spring could affect adult survival rates, and related impacts on pregnant females could affect reproductive success for some individuals. However, winter range is limited in the project analysis area for deer and elk. Disturbance during calving/fawning season (May - June) could affect neonate survival and recruitment. Alldredge (2000 cited in Peek 2003:885) reported that continuous disturbance of cow elk during calving season caused significant declines in calf survival rates. Disturbance on big game summer range would be associated with logging activities (burns would occur during spring or fall), including construction and use of roads. The project analysis area contains transitional habitat between big game seasonal ranges and is therefore used by migrating animals. Disturbance from project activities could influence behavioral and distribution patterns of big game during spring and fall migration periods. Since big game migration typically occurs in a dispersed pattern throughout the project analysis area (pers. comm. K. Alt 2009) animals displaced by project actions would likely find alternate routes through or around the treatment areas.

Big game vulnerability is influenced by both habitat alteration and disturbance factors. Reduced security cover could impact big game movement patterns and increase vulnerability to predation and hunting. In addition to cover removal, increased road density could facilitate hunter access and may also provide travel routes for predators such as wolves and bears (Ursus spp). Temporary roads constructed or reopened for access to the project analysis area would not be open to public motorized use, but could present easier travel routes for big game hunters on foot or horseback. Big game vulnerability to predation and hunting mortality is largely influenced by the combination of hiding cover and hunter access. Mechanical thinning and prescribed burning can increase site distance for hunters and predators, and make travel easier through areas that would otherwise be packed with dense trees, branches, and woody debris. Big game vulnerability has traditionally been described in the literature relative to mortality caused by humans during legal hunting seasons. However, with increasing populations of natural predators including wolves, bears and possibly mountain lions (Felis concolor), big game vulnerability is potentially more of an issue year round.

Christensen et al. (1993) provided considerations for evaluating and managing elk vulnerability to human mortality during hunting seasons. They provided a format for considering road access and juxtaposition of secure habitat. Secure habitat for elk was defined by Hillis et al. (1991:39) as areas at least 250 acres in size and at least one half mile from an open road. These authors recommended that at least 30% of an analysis area should be comprised of secure habitat in order to mitigate human hunting impacts. Public road access is extensive in the Hyalite portion of the project analysis area, but there is no public road access into Bozeman Creek. Administrative traffic associated with project implementation would occur on the main Bozeman Creek road and the connecter from Moser to Bozeman Creek, which would impact big game security in the Bozeman Creek drainage. Project roads needed to access treatment units would temporarily reduce big game secure habitat in the project analysis area under Alternatives 2, 3, 5 and 6.

During the travel management planning process, the Gallatin Forest Leadership Team recognized that multiple use management objectives preclude maximizing big game habitat potential relative to roads across all NFS lands. The Travel Plan Decision will effectively increase secure habitat for big game in some areas of the Forest, while maintaining secure habitat at or below 30% in others, to achieve a desired balance between the needs of wildlife, and opportunities for motorized recreation and access (USDA 2006, ROD:78). Christensen et al. (1993:3) acknowledged that local land management objectives would influence habitat effectiveness levels for big game, and that as a consequence, some areas would only provide minor contributions to big game habitat management goals.

Given the current road configuration authorized by the Gallatin Forest Travel Management Plan, the project analysis area is already below 30% secure habitat (currently at about 28% secure habitat under existing conditions). Combined with temporary road use associated with implementation of proposed treatment, the project analysis area would remain below 30% secure habitat under all alternatives, with temporary declines to 25% in Alternatives 3 and 5, 26% in Alternatives 2 and 6 and remaining at 28% in Alternatives 1 and 4. Since project roads would be closed upon completion of implementation, secure habitat conditions are expected to return to the existing condition.

To help mitigate disturbance impacts associated with timber harvest on elk summer range, Lyon and others (1982:viii) recommended including a provision for security areas adjacent to the project activity area during logging implementation and associated road use. They suggested that such areas should be at least 5,000 acres in size, easily accessed by elk displaced by project activities, and contain a large proportion of forest cover. There are large blocks of forested secure habitat available to big game adjacent to the project analysis area in South Cottonwood, Upper Hyalite and Upper Bozeman Creek. Secure habitat was evaluated using criteria outlined by Hillis et al (1991) for areas adjacent to, and roughly the same size as the project analysis area. To the north and east of the project analysis area, a 19,940 acre area at the north end of the Gallatin Range was considered. This area includes Bear Canyon, Chestnut Mountain, Mount Ellis, and Mystic Lake to the headwaters of Bozeman Creek near Palisade Mountain. This area currently contains approximately 51% secure habitat, and no known actions are currently planned that would change this figure. To the south and west of the project analysis area, a 25,260 acre area was evaluated for security habitat. This area includes South Cottonwood drainage to Wheeler Ridge, south to Timber Butte, east to Elephant Mountain, the Mummy, and Sleeping Giant Mountain to Palisade Mountain. This area is currently at about 45% secure habitat, with no known actions planned that would reduce secure habitat. The presence of these large secure habitat areas that are easily accessible by big game should help alleviate disturbance impacts associated with the project. Maps of secure habitat within and adjacent to the project analysis area are contained in the project file.

Direct and Indirect Effects of Alternative 2

Alternative 2 includes 3,339 acres of treatment that would convert dense forest cover to forested foraging habitat, changing the forage:cover ratio from 16:84 to 31:69, which is still skewed toward cover relative to Thomas' (1979:121) recommended optimal ratio of 60:40. Approximately 3,522 acres of hiding cover would be affected under this alternative, leaving roughly 82% of the habitat capable of producing hiding cover in a condition that would continue to provide cover. Of the hiding cover affected, 1,402 acres also meet the criteria for thermal cover. This alternative would retain 86% of the existing thermal cover in the project analysis area. Given the existing high level of public road access in lower Hyalite and high levels of recreation use throughout the project analysis area, a greater proportion of cover may be important to big game in the project analysis area. Of the increased forage areas likely to be produced by fuel treatment, all are expected to increase production of grasses and forbs used by elk and deer, while 2,684 acres are in shrub producing habitat types, which would be expected to benefit moose as well as deer and elk.

Montana Fish Wildlife and Parks goal for elk management in southwest Montana is to maintain habitat at or below 1 mi/mi^2 road density (Appendix K, ICST 2003:33). Again, the Gallatin Forest Travel Management Plan was developed with the understanding that optimal conditions for big game; e.g. no more than 1 mi/mi^2 road density, cannot be achieved on all NFS lands and still meet multiple use management objectives. The current Travel Plan-authorized road configuration in the project analysis area already exceeds 1 mi/mi^2 road density at 1.28 mi/mi^2. Alternative 2 includes approximately 7.2 miles of new temporary road construction, plus 3.0 miles of existing road re-opened for a total of 10.2 miles of additional open road in the project analysis area. Under this alternative, open road density would increase from 1.28 mi/mi^2 to 1.59 mi/mi^2 in the project analysis area. Including motorized use on single track trails, the total motorized access route density in the project analysis would increase from the existing 1.36 mi/mi^2 to 1.68 mi/mi^2. However, this increase would be temporary since project roads constructed for the BMW project would be quickly and effectively closed after project completion, as per direction in the Gallatin Forest Travel Management Plan.

Lyon et al. (1985:5) noted that elk show a preference for crossing over ridges at saddles and low divides, in areas where hiding cover is available. Alternative 2 involves some temporary road development near ridgelines and through saddles that could be important for big game movement. The areas affected in this alternative include short segments of temporary road that travel along and pass over the ridgeline between South Cottonwood drainage and Hyalite (in treatment unit 16), between Hodgeman Creek and Leverich Creek (unit 14) and between Leverich Creek and Bozeman Creek (unit 12). These road segments and associated harvest could impact big game movement within the project analysis area and/or between the project site and winter range. In addition to road locations on or near forested ridgelines, many treatment units are located near ridgelines, such that fuel reduction measures would reduce hiding cover along potentially important travel corridors for big game. However, as big game movement throughout the project analysis area typically occurs in a dispersed fashion, and many forested saddles and ridgelines within the area would not be affected by proposed treatments, no permanent barriers to wildlife movement are expected to result from implementation of this alternative.

Cumulative Effects of Alternative 2

Cumulative effects of past actions that have altered big game habitat were considered in evaluation of baseline habitat conditions for the project analysis area; e.g. the amount and distribution of forage and cover currently available, plus current motorized access configurations. Past actions or events that have produced the existing habitat characteristics in the project analysis area include timber harvest, livestock grazing, prescribed burns, wildfires, and fire suppression, as well as residential, administrative and recreational facility development. Reasonably foreseeable future actions that could have similar effects on big game in the project analysis area include potential fuel reduction projects on City and private lands. We have no detailed information for any potential future vegetation treatment on private land; however, the City of Bozeman is considering fuel reduction treatment on approximately 640 acres in the project analysis area. Such treatment would affect about 560 acres of hiding cover. When this action is combined with the federal BMW proposal, about 79% of the capable habitat in the project analysis area would be maintained in a condition that would continue to provide hiding cover. Road densities in the project analysis area could be affected by the City proposal, but there is not enough information available currently to accurately quantify potential impacts.

Current motorized access route (road and trail) configuration in the project analysis area is a result of Travel Management Planning at the Forest-wide scale. Such planning efforts took a multitude of variables, including big game habitat management, into consideration. Full implementation of the (2006) Gallatin Forest Travel Management Plan includes some minor trail construction to connect loop opportunities for motorized (ATV, motorcycle) and non-motorized (mountain bike, hikers, horseback) recreation. It also involves the decommissioning (closure) of many miles of old roads and user-built trails in the project analysis area. Motorized route densities presented in this report were calculated to reflect full implementation of the Travel Plan, which ultimately reduces overall motorized access route density in the project analysis area. Road density and associated big game secure habitat analyses were confined to the project analysis area described under "Spatial Analysis Boundary" earlier in this section. However, for additional information, a detailed analysis of road density impacts on big game is presented in the Gallatin National Forest Travel Management Plan FEIS, Volume 2, Chapter 3. Analysis for Hunting District 301 (Hyalite-Portal) is on pp. 3-24 and 3-25. The City of Bozeman proposal includes some potential new road construction to access harvest units as well as possible reconstruction of old roads. Road locations and lengths are estimated for some areas, but are not known, or depend on access across private land in other locations. For these reasons, there is insufficient information available to accurately quantify impacts on road density and/or secure habitat.

Livestock (primarily cattle) grazing has occurred in the project analysis area for decades, continues at present and will remain as an accepted land use practice into the foreseeable future. Current livestock allotments in the project analysis area are limited to the Hyalite drainage, although some trespass occurs on a regular basis into Bozeman Creek, largely due to fences left down by recreationists, or broken down by wildlife. Livestock grazing can affect forage availability for big game, although the Forest Plan contains livestock utilization standards designed to retain adequate forage for wild ungulates. Livestock are attracted to improved forage conditions in disturbed areas and may compete with wild ungulates for increased forage in fuel treatment areas. Big game distribution patterns can also be impacted by livestock. Elk tend to avoid cattle and will move out of suitable habitat to segregate themselves (Lyon et al. 1985:13). Mackie et al. (2003:901) noted that mule deer are particularly susceptible to adverse effects from livestock presence during the fawning season. Livestock impacts on moose would be associated with cattle congregating in riparian areas and either browsing or trampling willow. Fences built to contain cattle within allotment boundaries can restrict wildlife movement within and between seasonal ranges. There is livestock fence on the divide between Hyalite and Bozeman Creek and also on the divide between Hyalite and South Cottonwood. These gentle ridgelines provide important travel routes for wild ungulates, and fencing could affect big game movement patterns. However, these ridgeline fences are only up while cattle are on the allotments, generally during the summer, when many big game animals move to better quality summer range at higher elevations outside of the project analysis area.

Hyalite Canyon and Bozeman Creek receive some of the highest recreation use on the Gallatin Forest, and even in the USDA Forest Service Northern Region. Recreation impacts contribute disturbance effects to big game through human presence and noise associated with motorized and non-motorized recreation. Big game hunting, which is popular in both drainages, strongly influences mortality rates, and consequently has a major effect on big game populations. Montana Fish Wildlife and Parks personnel closely manage hunting quotas to provide sustainable big game populations. Recreation levels in the project analysis area have increased notably in recent years, are currently high, and are expected to continue to increase commensurate with human population growth in Gallatin Valley and across the country.

Direct and Indirect Effects of Alternative 3

Alternative 3 includes 5,150 acres of treatment that would convert dense forest cover to forested foraging habitat, changing the forage:cover ratio from 16:84 to 40:60, which is much closer to Thomas' (1979:121) recommended optimal ratio of 60:40. Approximately 5,407 acres of hiding cover would be affected under this alternative, leaving roughly 72% of the capable habitat in the analysis area in a condition where it would continue to provide hiding cover. Of the hiding cover affected, 2,501 acres also meet the criteria for thermal cover. This alternative would retain 75% of the existing thermal cover in the project analysis area. Given the existing high level of public road access in lower Hyalite and high levels of recreation use throughout the project analysis area, cover may be of considerable importance to big game. Of the increased forage areas likely to be produced by fuel treatment, all are expected to increase production of grasses and forbs used by elk and deer, while 4,266 acres are in shrub producing habitat types, which would be expected to benefit moose as well as deer and elk.

Alternative 3 includes approximately 13.5 miles of new temporary road construction, plus 5.4 miles of existing road re-opened for a total of 18.9 miles of additional open road in the project analysis area. Open road density would increase from 1.28 mi/mi^2 to 1.87 mi/mi^2 in the project analysis area. Including motorized use on single track trails, the total motorized access route density in the project analysis area becomes 1.95 mi/mi^2. Temporary project roads constructed for the BMW project would be quickly and effectively closed after project completion, as per direction in the Gallatin Forests Travel Management Plan.

Alternative 3 includes the same temporary road development near ridgelines and through saddles described above for Alternative 2, plus an additional road segment that affects the ridgeline between Hodgeman and Leverich Creeks in unit 14, and another segment that crosses through a saddle on the ridge between Hyalite and Hodgeman Creek (between units 25 and 15). These road segments and associated harvest could impact big game movement. In addition to road locations on or near forested ridgelines, many treatment units are located near ridgelines, such that fuel reduction measures would reduce hiding cover along potentially important travel corridors for big game. However, no permanent barriers to wildlife movement are expected to result from implementation of this alternative.

Cumulative Effects of Alternative 3

Basically the same as described above for Alternative 2. However, considering the combined effects of BMW fuel reduction with treatment proposed on City lands, roughly 70% of the capable habitat in the project analysis area would be maintained as hiding cover under Alternative 3.

Direct and Indirect Effects of Alternative 4

Alternative 4 includes 4,258 acres of treatment that would convert dense forest cover to forested foraging habitat, changing the forage:cover ratio from 16:84 to 36:64, which brings the mix closer to Thomas' (1979:121) recommended optimal ratio of 60:40. Approximately 4,450 acres of hiding cover would be affected under this alternative, leaving roughly 77% of the capable habitat in the analysis area as hiding cover. Of the hiding cover affected, 2,094 acres also meet the criteria for thermal cover. This alternative would retain 79% of the existing thermal cover in the project analysis area. Given the existing high level of public road access in lower Hyalite and high levels of recreation use throughout the project analysis area, cover may be of greater importance to big game. Of the increased forage areas likely to be produced by fuel treatment, all are expected to increase production of grasses and forbs used by elk and deer, while 3,689 acres are in shrub producing habitat types, which would be expected to benefit moose as well as deer and elk.

No new roads would be built for project implementation under this alternative, so road densities and secure habitat would remain the same as under the No Action alternative. As in Alternatives 2 and 3, this alternative includes many treatment units near ridgelines, such that fuel reduction measures would reduce hiding cover along potentially important travel corridors for big game. However, no permanent barriers to wildlife movement are expected to result from implementation of this alternative.

Cumulative Effects of Alternative 4

Basically the same as described above for Alternative 2. However, considering the combined effects of BMW fuel reduction with treatment proposed on City lands, roughly 74% of the capable habitat in the project analysis area would be maintained as hiding cover under Alternative 4.

Direct and Indirect Effects of Alternative 5

Alternative 5 includes 4,842 acres of treatment that would convert dense forest cover to forested foraging habitat, changing the forage:cover ratio from 16:84 to 38:62, which is closer to Thomas' (1979:121) recommended optimal ratio of 60:40. Approximately 5,075 acres of hiding cover would be affected under this alternative, leaving roughly 74% of the capable habitat in the analysis area as hiding cover. Of the hiding cover affected, 2,517 acres also meet the criteria for thermal cover. This alternative would retain 74% of the existing thermal cover in the project analysis area. Given the existing high level of public road access in lower Hyalite and high levels of recreation use throughout the project analysis area, cover may be of greater importance to big game in the project analysis area. Of the increased forage areas likely to be produced by fuel treatment, all are expected to increase production of grasses and forbs used by elk and deer, while 4,126 acres are in shrub producing habitat types, which would be expected to benefit moose as well as deer and elk.

Alternative 5 includes approximately 7.0 miles of temporary project road construction, plus 1.7 miles of existing road re-opened for a total of 8.6 miles of additional open road in the project analysis area. Open road density would increase from 1.28 mi/mi^2 to 1.55 mi/mi^2 in the project analysis area. Including motorized use on single track trails, the total motorized access route density in the project analysis area becomes 1.63 mi/mi^2. Temporary project roads constructed and reconstructed for the BMW project would be quickly and effectively closed after project completion, as per direction in the Gallatin Forests Travel Management Plan.

Alternative 5 includes some temporary road development near ridgelines and through saddles, although less than under Alternatives 2 or 3. The areas affected in this alternative include short segments of temporary road that travel along and pass over the ridgeline between South Cottonwood drainage and Hyalite (in treatment unit 16), between Hodgeman Creek and Leverich Creek (unit 14) and just north of Moser Creek (access unit 21). These road segments and associated harvest could impact big game movement. In addition to road locations on or near forested ridgelines, many treatment units are located near ridgelines, such that fuel reduction measures would reduce hiding cover along potentially important travel corridors for big game. However, no permanent barriers to wildlife movement are expected to result from implementation of this alternative.

Cumulative Effects of Alternative 5

Basically the same as described above for Alternative 2. However, considering the combined effects of BMW fuel reduction with treatment proposed on City lands, roughly 71% of the capable habitat in the project analysis area would be maintained as hiding cover under Alternative 5.

Direct and Indirect Effects of Alternative 6

Alternative 6 includes 3,888 acres of treatment that would convert dense forest cover to forested foraging habitat, changing the forage:cover ratio from 16:84 to 34:66, which would bring the project analysis area closer to Thomas' (1979:121) recommended optimal ratio of 60:40. Approximately 4,090 acres of hiding cover would be affected under this alternative, leaving roughly 79% of the capable habitat in the analysis area as hiding cover. Of the hiding cover affected, 1,771 acres also meet the criteria for thermal cover. This alternative would retain 82% of the existing thermal cover in the project analysis area. Given the existing high level of public road access in lower Hyalite and high levels of recreation use throughout the project analysis area, cover may be more important to big game here than in areas of lower overall human use. Of the increased forage areas likely to be produced by fuel treatment, all are expected to increase production of grasses and forbs used by elk and deer, while 3,322 acres are in shrub producing habitat types, which would be expected to benefit moose as well as deer and elk.

Alternative 6 includes approximately 7.1 miles of temporary project road construction, plus 3.1 miles of existing road re-opened for a total of 10.2 miles of additional open road in the project analysis area. Open road density would increase from 1.28 mi/mi^2 to 1.59 mi/mi^2 in the project analysis area. Including motorized use on single track trails, the total motorized access route density in the project analysis area becomes 1.68 mi/mi^2. Temporary project roads constructed and reconstructed for the BMW project would be quickly and effectively closed after project completion, as per direction in the Gallatin Forests Travel Management Plan.

Alternative 6 includes some temporary road development near ridgelines and through saddles, although less than under Alternatives 2, 3 or 5. The areas affected in this alternative include short segments of temp road that cross over the ridgeline between South Cottonwood drainage and Hyalite in treatment units 16A and 16C, between Hodgeman Creek and Leverich Creek in unit 13C and on the west side of Hyalite, across from Buckskin Creek accessing unit 20. These road segments could impact big game movement. In addition to road locations on or near forested ridgelines, Alternative 6 includes the concept of ridgeline fuelbreaks, in which the prescription calls for heavier thinning (removal of 70-80% woody biomass) along the ridgeline than in adjacent treatment units. Ridgeline fuelbreaks are scattered throughout the project analysis area in this alternative, affecting a total of approximately 8.3 miles of forested ridgeline, and account for roughly 369 acres of treatment. Ridgeline fuelbreaks would remove hiding cover along potentially important travel corridors for big game. However, cover would be retained along many forested ridgelines and saddles throughout the project analysis area. Due to the dispersed nature of big game movement throughout the project analysis area, and since many forested ridges and saddles would not be affected by proposed treatment, no permanent barriers to wildlife movement are expected to result from implementation of the proposed action.

Cumulative Effects of Alternative 6

Basically the same as described above for Alternative 2. However, considering the combined effects of BMW fuel reduction with treatment proposed on City lands, roughly 76% of the capable habitat in the project analysis area would be maintained as hiding cover under Alternative 6.

Comparison of Alternatives

Alternative 1 would have no direct habitat alteration or disturbance impacts on big game. However, the No Action alternative would not improve forage conditions for big game. Alternative 2 would have the least reduction of hiding cover among the alternatives, including cover along forested ridgelines that provide important travel routes for big game. Conversely, Alternative 2 would have the least amount of potential forage improvement among the action alternatives. Temporary project road construction and use, coupled with noise from heavy equipment used for commercial timber harvest in Alternatives 2, 3, 5 and 6 would have greater disturbance impacts to big game than would occur under Alternative 4. Alternatives 3, 5 and 6 could result in considerable increases in foraging habitat, but at the expense of reductions in hiding cover, additional temporary road construction and potential for ongoing project activities to displace big game from suitable habitat. With the addition of ridgeline fuelbreaks, Alternative 6 could have a greater impact on big game movement and distribution than other alternatives.

Like the other action alternatives, Alternative 4 would increase forage quantity and quality in the project analysis area. Hiding cover would be reduced, but cover is not limited in the project analysis area, and would still remain relatively high after project implementation. Alternative 4 would have no negative impacts associated with road construction or use, but could have disturbance impacts in secure habitat, and would also impact cover along ridgeline travel corridors. Alternative 4 would use prescribed burning as opposed to logging in mature forest stands. Burning typically results in a mosaic pattern with dense patches of trees retained and larger openings created, whereas commercial thinning can result in more even spacing between trees. Prescribed burning typically results in vegetation structure that more closely mimics natural disturbance patterns, and which may therefore be more familiar to big game species. Of all the alternatives, including the no action, Alternative 4 would likely have the most potential to benefit big game species by increasing forage amount and quality relative to cover availability, with the fewest disturbance impacts among the action alternatives.

Compliance with Applicable Direction

All alternatives would meet Forest Plan direction to provide habitat for big game. Forest-wide standards would be met for managing forage and cover needs for all species in coordiantion with other uses (per Forest Plan standard 6.a.3, p. II-18), while still maintaining at least 2/3 of the hiding cover in the project analysis area under all alternatives. It should be noted that Forest Plan standards apply to National Forest land that is administered by the Gallatin National Forest (GNF Plan p. II-14). However, for the hiding cover retention standard (6.a.5. p. II-18), we included all lands within the project analysis area in the baseline calculation and also considered how activities (past, present and reasonably foreseeable) on other (non-federal) lands would affect the proportion of cover maintained throughout the project analysis area. All action alternatives include prescriptive mitigation measures to maintain hiding cover associated with discrete key habitat features such as meadows, wallows, etc. in order to meet Forest Plan standard 6.a.5.(FEIS p. 2-22) In addition, Streamside Management Zone mitigation (Appendix A) would further protect moist key habitat features by leaving a non-treated buffer along stream banks, where moist vegetation types are likely to occur.

Forest Plan direction specific to Management Areas (MA) within the project analysis area (MA 5, 7, 8, 9, 12 and 17) would also be met. Forest Plan standards relevant to big game in these MAs tends to be more general than Forest-wide standards. MA 5 contains Goals to maintain and improve wildlife habitat values but also to allow timber harvest, along with a standard that allows for habitat improvement projects consistent with these goals. While treatment prescriptions are not specifically designed to improve wildlife habitat, some short term benefits are expected for big game species as a result of increased forage production where dense forest canopies are opened up. MA 7 contains a standard to maintain suitable habitats for those species of birds, mammals and fish that are totally or partially dependent upon riparian areas for their existence. Riparian habitat is also important to big game animals. This standard would be met through mandatory compliance with Best Management Practices and observance of Streamside Management Zones (see Aquatic Mitigation Measures, #3, Ch. 2-17 and Appendix B, Stream Management Zone Guidelines, p. B-12).

MA 8 focuses on timber production and allows for habitat improvement projects consistent with timber production goals and objectives, but requires incorporation of Forest-wide standards for wildlife. Applicable Forest-wide standards would be met as described above. MA 9 provides for a variety of dispersed recreation activities, and allows for wildlife habitat improvement consistent with recreation goals. Again, proposed treatments were not designed to improve wildlife habitat, but increased forage production for big game coupled with increased visibility due to reductions in forest cover could improve wildlife viewing and hunting opportunities for the public. MA 12 contains a goal to maintain and improve the vegetative condition to provide habitat for a variety of wildlife, and a standard to schedule vegetation management practices to meet this goal. Proposed fuel treatment would break up the forest canopy, create small openings and stimulate forage production in an area currently dominated by mature, closed forest habitat. Resulting habitat alteration would increase habitat structural diversity for big game and other wildlife species. MA 17 focuses on livestock management and coordinating habitat needs of wildlife and livestock. Proposed fuel reduction treatment would increase forage availability and improve forage quality for both wildlife and livestock. Wildlife use in the project analysis is highest during spring and fall, whereas livestock use of the area is concentrated in summer.

Direction contained in the Gallatin Forest Travel Management Plan would be met for temporary project roads by using gates or other barricades during project implementation to restrict public motorized use, and by permanently and effectively closing temporary project roads upon completion of the fuels treatment and associated management activities.

Summary Conclusion

All alternatives would meet current applicable direction, yet all could pose both positive and negative effects to big game. Elk populations are stable to increasing when considered at the small scale (BMW project analysis area) and at the large scale (Gallatin National Forest). However, when considered at a mid-scale range, e.g. looking at the Gallatin Mountain Range, it should be noted that there is growing concern about the impact of wolf predation on elk numbers, distribution and behavior. Elk numbers in the upper Gallatin (south of the BMW project analysis area) have shown a relatively steady decline in recent years (USDA 2011b). Combined effects of wolf predation throughout the Gallatin Range, plus fuel reduction and other vegetation management projects proposed at the north end of the Gallatin Range where elk numbers are holding steady, could further impact elk numbers in the future.

However, to do nothing about fuel buildup in an area affected by past fire suppression and recent insect infestation could also have undesirable impacts on elk numbers in the Gallatin Range. A large scale fire event in the BMW project analysis area could easily reduce hiding and thermal cover to a much greater degree than would occur as a result of proposed fuel reduction treatment. Cover is not currently limiting in the project analysis area. Disturbance impacts and reductions in secure habitat resulting from proposed management actions would be temporary (5 - 10 years) and at least two thirds of the capable habitat in the project analysis area would be maintained as hiding cover. A large scale fire event could easily reduce cover to well below two thirds of the analysis area, and would take approximately 20 – 40 years to regenerate to a point where it again provides cover. Such a large scale reduction in cover, while possibly providing short-term increases in forage, would not be a net benefit for elk and other big game in the Gallatin Range.

Issue: Fisheries/Aquatic Species

Changes between Final and Supplemental EIS:

This analysis replaces the fisheries analysis in the FEIS (p. 3-53 to 3-92) in its entirety.

New projections in sediment delivery rates are displayed in the Water Quality section of the SFEIS as a result of recent road decommissioning and sediment model coefficient adjustments for thinning and broadcast burning units. Subsequently, new projections for percent fine sediment and percent egg-to-fry survival were made throughout the Environmental Effects section of the Fisheries analysis.

In the most recent update to the Region 1 sensitive species list (USDA-FS 2004), fluvial Arctic grayling was removed from the sensitive species list on the Gallatin National Forest and western pearlshell mussel was added to the list for all National Forests within their native range. In the Biological Evaluation section of this report, the potential effects from the preferred alternative are discussed for western pearlshell mussel.

In a recently written document entitled “Distribution and Status of Gallatin National Forest Aquatic Management Indicator Species”, available in the project record, it was determined that wild redd spawning trout (classified as Management Indicator Species) are widespread and common or abundant on the Gallatin National Forest within the Yellowstone and upper Missouri River drainages (GNF 2010). In general, aquatic habitats are being maintained across the Gallatin National Forest sufficient to support coldwater fisheries as required by the Clean Water Act. This information was incorporated throughout the Environmental Effects discussion.

Introduction and Statement of Issue

This report addresses the potential effects of the proposed Bozeman Municipal Watershed Fuels Reduction Project on the fishery and aquatic resources within the project area. The potential effects on amphibians were addressed in a separate analysis. Affected environment descriptions and environmental analyses are based on general reviews of the project area, site-specific field reviews, fish habitat surveys, fish population surveys, and sediment delivery modeling. This analysis addresses standard aquatic resource issues identified for fuels reduction projects and those identified by public scoping that have the potential to affect fish populations and habitats those populations are dependent upon.

Issue: Fuel reduction activities, including harvesting, thinning, prescribed burning and associated activities, may:

- **Disturb soils and overland flow regimes,** which, in turn increases the potential for erosion and sediment transport to streams and other water bodies. Increased fine sediment in streams and other water bodies can reduce habitat quality and cause adverse effects to fish and other aquatic biota.

  For example, elevated levels of fine sediment (material < 6.35 mm in diameter) have been shown to affect salmonid habitat used for spawning, rearing and overwintering (Chapman and McLeod 1987). Increasing proportions of fine sediment in substrates have been associated with reduced intra-gravel survival of embryos for brook trout (Hausle and Cobble 1976; Alexander and Hansen 1986), and rainbow trout (Witzel and MacCrimmon 1981; Irving and Bjornn 1984). The effect of fine sediment on survival of incubating cutthroat trout has been studied less than for other salmonid species. In laboratory studies, Irving and Bjornn (1984) found that elevated fine sediment (less than 6.35 mm) levels significantly reduced survival of cutthroat trout. Pools are areas of higher velocity during peak flows, but at low flows their depth creates a depositional environment for fine sediment. Increased sediment from timber harvest and road construction could influence the amount and quality of juvenile and adult pool habitat if sediment increases are sufficient to alter channel morphology by filling in pools. For lower gradient sensitive stream channel types with high sensitivity to increased sediment, excessive sediment loading can reduce maximum pool depth and residual pool volume.

Indicators to evaluate potential effcts to sediment delivery on wild trout (MIS) and potential impacts to westslope cutthroat trout (sensitive spcies).

1. Percent over Natural (or Reference) Sediment Delivery rates compared to the Gallatin National Forest Travel Plan standard established for Class A streams. Meeting the standard would assure that the 90% spawning habitat management objective is being achieved.

2. Incremental changes in fine sediment deposition in spawning gravels associated with predicted sediment yield changes. Resulting values are not considered definitive or absolute; rather they are used to evaluate the relative magnitude and direction of incremental change in spawning habitat and as a means to make relative comparisons between alternatives.

3. Meeting the intent of the Implementation Strategy for Memorandum of Understanding and Conservation Agreement (MOUCA) for Westslope Cutthroat Trout in Montana by protecting all pure and slightly introgressed (90% or greater purity) westslope cutthroat trout populations and ensuring the long-term persistence of westslope cutthroat within their native range (Powell 2002). Because Leverich Creek is the only project area stream that contains westslope cutthroat trout, this indicator only applies to this analysis area.

4. Comparison of the weighted probability that a stand replacing and mixed severity fire will occur within the Leverich Creek drainage at 10 to 20 years from now.

The following concerns were considered but would be effectively mitigated or the potential impact from the project would be negligible, therefore they were dropped from further analysis.

Fuel reduction activities, including harvesting, thinning, prescribed burning and associated activities, may: affect fish habitat and biological productivity by reducing the number of larger trees that fall in to mountain streams. Large woody debris is the primary pool-forming feature in forested, moderate gradient stream channel types. Removal of riparian trees can reduce the potential to recruit trees into the stream channels and alter stream temperatures. This proposal contains no riparian timber harvest, therfore, potential effects to habitat attributes related to riparian vegetation will not be analyzed, such as large woody debris recruitment, alteration of stream temperatures, and changes of stream bank stability from near bank activities or water yield changes.

Fuel reduction activities, including harvesting, thinning, prescribed burning and associated activities, may: increase water yield and the magnitude or duration of peak flow by altering a variety of hydrologic processes. This hydrologic imbalance could adversely affect aquatic habitat through increased scour potential, channel incision, bank erosion and increased sediment transport capacity. Changes in water yield are discussed separately in the water quality section of this SFEIS. Significant changes in timing and water yield would not be a result from the implementation of any of the five action alternatives.

Summary

The focus of the fisheries analysis centers on the Leverich Creek drainage as a result of the recently discovered westslope cutthroat trout. Leverich Creek is a relatively short drainage that flows northward between Hyalite and Bozeman creeks. The majority of the mitigation measures resulting from the fisheries analysis were designed around the Leverich Creek analysis area.

Because the action alternatives contain no riparian timber harvest, potential effects to those habitat attributes related to riparian vegetation will not be analyzed, such as large woody debris recruitment, alteration of stream temperatures, and changes of stream bank stability from near bank activities. The effects analysis centered around sediment delivery on wild trout (Management Indicator Species) and Sensitive Species (westslope cutthroat trout).

<u>Short-term Effects</u>

All five action alternatives (Alternatives 2 thru 6) would meet the Forest Plan standard for sediment delivery in the Hyalite and Bozeman Creek analysis areas. Alternatives 4 thru 6 would also meet this standard within the Leverich Creek analysis area, but Alternatives 2 and 3 would exceed the standard and would require a site-specific Forest Plan amendment to be implemented (SFEIS, Table 10).

Projected changes in percent fine sediment in the Leverich Creek analysis area would be less than 1 percent for Alternatives 4, 5 and 6. Projected changes in percent fine sediment would exceed 6.0% for Alternatives 2 and 3. Percent fine sediment is projected to be reduced by 1 percent taking into account all watershed restoration activities within the Leverich Creek analysis area (SFEIS, Table 9). Alternative 5 would include a helicopter landing at the Leverich Creek trailhead. This would require enlarging the existing trailhead and removing several streamside trees to improve the helicopter flight corridors. Projected sediment delivery in Leverich Creek would increase by only 0.9 percent as a result of increased acres and the trailhead landing.

Projected changes in percent fine sediment in the Hyalite and Bozeman Creek analysis areas would be less than 1 percent for all action alternatives. Percent fine sediment is projected to be reduced by 0.5 percent taking into account all watershed restoration activities within the Hyalite Creek analysis area (SFEIS, Table 9).

Alternatives 4, 5, and 6 would meet the intent of the Memorandum of Understanding and Conservation Agreement for Westslope Cutthroat Trout in Montana (Powell 2002) and Alternatives 2 and 3 would not. These determinations are primarily related to projected short-term sediment related effects (SFEIS, Table 10).

Long-term Effects

All five action alternatives reduce the probability and severity of fire within the Leverich Creek drainage as compared to the No Action Alternative. Alternative 3 would result in the lowest weighted probability of a stand replacing and mixed severity fire within Leverich Creek Drainage (10 to 20 yr.).

Overall, Alternative 6 represents the best balance between minimizing short-term sediment related effects and long-term benefits related wildfire impacts for fisheries.

Background

Affected Environment

Bozeman Creek and Tributaries

The Bozeman Watershed Council in their 2004 Sourdough Creek Watershed Assessment (Map 8, Bozeman Watershed Council, 2004) delineated the segment of Bozeman Creek (also known as Sourdough Creek) from the Forest boundary upstream to the South Fork as Reaches 7 thru 9. Rainbow trout (Oncorhynchus mykiss), brook trout (Salvelinus fontinalis), and brown trout (Salmo trutta) inhabit this segment. Yellowstone cutthroat trout (Oncorhynchus clarkii bouvieri) have been noted upstream above and below Mystic Lake. Most likely mottled sculpin (Cottus bairdi), longnose dace (Rhinichthys cataractea) and longnose sucker (Catostomus catostomus) also inhabit Bozeman Creek around the intake. Rainbow trout and brook trout were estimated to number 72 fish and 144 fish/1000 feet, respectively, in 1980 near the Forest boundary (Montana Fisheries Information System, 2006). Subsequent data collection in 1998 (believed to be along the same reach of stream) yielded similar relative abundance estimates between brook trout and rainbow trout. The population structure of both species was made up of several age classes.

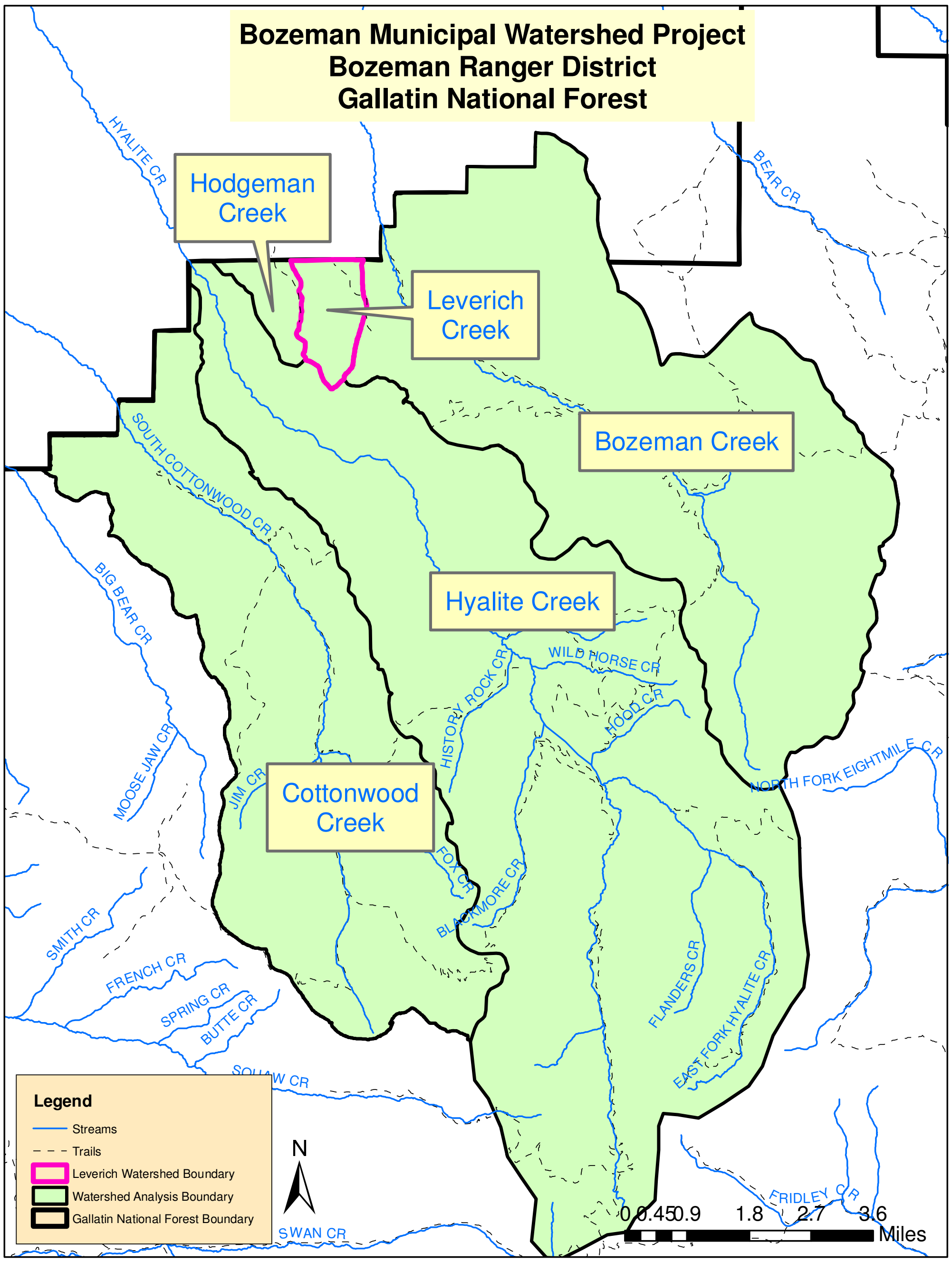
There are two migration barriers along this segment of Bozeman Creek including a natural 5.0 meter high falls and the water intake diversion for the City of Bozeman. Both are barriers to upstream migrating fish. It is presumed that the natural falls also limited the upstream migration of native westslope cutthroat trout (Oncorhynchus clarki lewisi). It is presumed that westslope cutthroat trout inhabited Bozeman Creek up to this fall prior to the stocking of non-native trout. No native westslope cutthroat trout or westslope cutthroat trout hybrids have been observed or collected within this watershed either above or below that natural barrier.

Rainbow trout and brook trout also inhabit two small unnamed 1st and 2nd order tributaries that drain the east side midway between the water intake and the South Fork. Based on the size structure of fish collected, it appears both of these streams are used primarily for spawning and summer rearing.

Bozeman Creek from the Forest boundary upstream to the South Fork is a forested, low (< 2%) to moderate (2-4%) gradient stream dominated by gravel and cobble. The stream channel ranges from a meandering, gravel dominated stream channel type (C4) to a moderate gradient, cobble dominated stream type (B3) (Rosgen, 1998). At the Forest boundary, Bozeman Creek is a 3rd order stream with an average channel width of 5 to 6 meters and an average depth of 15 cm at base flow. The Sourdough Creek Watershed Assessment

(Bozeman Watershed Council, 2004) concluded that pool frequency along Bozeman Creek between the intake and the South Fork is similar to reference conditions, although, deeper overwintering pools used by trout are lacking most likely a result of the low occurrence of large woody debris. Surface fine sediment estimates increased from 20% just below the South Fork to 30% just above the water intake.

Figure 3. Five fisheries and watersheds analysis areas.



This increase is thought to be a result of the close proximity of the adjacent road and lower stream energy. Recommendations and rehabilitation opportunities discussed in this watershed assessment included reducing erosion from the road, riparian vegetation planting, large woody debris placement, bank stabilization and improvement of head gates.

Leverich Creek

Leverich Creek is a small 1st order stream that drains the face overlooking Gallatin Valley between Bozeman Creek and Hyalite Creek. On the USGS topographical map, the left fork is considered Leverich Creek. During a September 2006 site visit, this fork was dry near the confluence with the right fork. All the water was coming down the right fork. It appears from the USGS topographic map that Leverich Creek once naturally drained in to Bozeman Creek downstream of the Forest boundary and the City of Bozeman's water treatment plant. Leverich Creek is presently bisected by several cross ditches on private land. It is not known if Leverich Creek still reaches Bozeman Creek. This small stream was sampled for the first time in September, 2006. Both brook trout and westslope cutthroat trout were collected. Leary and Powell (2007) determined that both of the westslope cutthroat trout were indeed genetically pure. To be 99 percent sure that the population of westslope cutthroat trout is genetically pure, a sample of 50 tissue samples would have to be tested. Further sampling was conducted below the Forest boundary in October 2006 to determine the full extent and health of this potentially pure population of westslope cutthroat trout. Approximately 450 meters of Leverich Creek were sampled with only one additional westslope cutthroat trout being observed compared to 57 brook trout. Both westslope cutthroat trout and brook trout inhabit Leverich Creek in low densities.

Additional fish sampling was conducted in 2007 to document the population size, distribution, and genetic purity of the population of westslope cutthroat trout that inhabits Leverich Creek. It was determined that the population of westslope cutthroat trout is distributed over 1,788 meters (1.11 miles) with the majority or core population being located above a small partial barrier in the upper 803 meters (0.50 miles). These lengths are valley bottom measurements, not actual stream lengths which are probably longer. Two population estimates were conducted near the middle and upper end of this 803 meter reach. The population estimate in the middle of fish greater than 75 mm was 21.0 per 100 m (fish ranging between 70-155 mm) as compared to 32.2 fish per 100 m (fish ranging between 71-130 mm) at the upper end. If these population estimates are indicative of the entire 803 meter reach, it is estimated that 213 westslope cutthroat trout greater that 75 mm presently occupy upper Leverich Creek above the small partial barrier. The overall population was skewed heavily to a single age group ranging in length from 70-100 mm. Fish as small as 40 mm and as large as 240 mm were also collected during electrofishing efforts outside the population estimate reaches. Fifty additional tissue samples were sent into the University of Montana Salmon and Trout Genetics lab for genetic analysis. These fish were determined to be 99% genetically pure slightly hybridized with rainbow trout.

Based on this initial survey work, it appears that eastern brook trout are expanding further into the headwaters displacing westslope cutthroat trout. The fact that few westslope cutthroat trout are present below a partial barrier where eastern brook trout dominate the fishery and westslope cutthroat trout dominate the fishery above the barrier is evidence suggesting that eastern brook trout are displacing westslope cutthroat trout and limiting the population. This population of cutthroat trout is isolated from its nearest neighbor as a result of nonnative invasion and other contributing factors such as water diversions, road culverts, hybridization, etc. Without costly and controversial management activities, it is unlikely this population will ever be reconnected with its nearest neighbor.

Leverich Creek above the Forest boundary is a small (0.85 m wide), moderate gradient stream (2-4%) dominated by small gravel (B3 stream channel type). The stream above this point is lacking large woody debris. Subsequently, the frequency of deeper overwintering pools is low. Below this point, riparian brush and deciduous tree species are thick resulting in an abundance of small woody debris (or branches). Because of the small stream size, small woody debris remains within the stream channel. This abundance of small woody debris appears to be slowing water velocity trapping accumulations of smaller sized gravel and sand. In places, these accumulations appear to be filling deeper overwintering pool habitat used by trout. Low density of trout within lower Leverich Creek most likely is a result of small stream size and lack of deeper overwintering pools.

Five sediment core samples were also collected in 2007 and analyzed from a short reach of Leverich Creek between the forks and the National Forest boundary. It was later determined that 22.9% of spawning substrate is made up of fine materials less than 6.3 mm. These five samples ranged from 18.0 to 32.0% (Std. Dev. = 5.37). This meets the Gallatin National Forest Travel Plan sediment objective for Category A streams.

Hyalite Creek

Rainbow trout dominate the trout fishery in Hyalite Creek (also known as Middle Creek) near Langohr Campground. Rainbow trout population estimates made in 2000 displayed in Table 1 are similar to estimates from 1990, 1992, and 1993 and higher than the estimate made in 1997.

Table 1. Density of rainbow trout and brook trout in Hyalite Creek in two 1000 foot reaches above and below Langohr Campground in August, 2000.

Size Class (mm	Lower Langohr Campground		Upper Langohr Campground	
	Rainbow Trout (#/1000 feet)	Brook Trout (#/1000 feet)	Rainbow Trout (#/1000 feet)	Brook Trout (#/1000 feet)
89-165 mm (3.5-6.49 in.)	397	1	307	69
165 – 241 mm (6.5 – 9.49 in.)	217	11	263	31
> 241 mm (9.5 in.)	46	1	29	7

Because of the higher stream gradient along Hyalite Creek, it is presumed that rainbow trout dominate the fishery from FS Road # 1046 (Langohr Road) downstream to the water diversion for the City of Bozeman intake just above the Forest boundary. In addition to these two species, brown trout, mottled sculpin, longnose dace, longnose sucker, mountain sucker

(Catostomus platyrhynchus) and mountain whitefish (Prosopium williamsoni) have all been collected in Hyalite Creek (Montana Fisheries Information System, 2006). Lacustrine (or lake dwelling) Arctic grayling (Thymallus arcticus) and Yellowstone cutthroat trout inhabit Hyalite Reservoir and tributaries above the dam. Because of the close proximity to the Hyalite Canyon Road (FS Road # 62) and Langohr Campground, Hyalite Creek is heavily fished during the summer months. Westslope cutthroat trout do inhabit two tributaries to Hyalite Creek just below Middle Creek Dam: Lick Creek and Wildhorse Creek. The Lick Creek population is significantly hybridized (> 10%) while the Wild Horse Creek population is genetically pure. Both these populations are located above partial or completed barriers upstream of any proposed treatment units and project related impacts.

Hyalite Creek within the project area is a moderate (2-4%) to high gradient (> 4%) stream, dominated by gravel, cobble and boulders along the higher gradient reaches. The stream channel ranges from a moderate gradient, cobble dominated stream channel type (B3) to a high gradient, boulder dominated stream type (A2) (Rosgen, 1998). At the Forest boundary, Hyalite Creek is a 4th order stream. Roads, logging activities, splash dams, cattle grazing, water storage, changes to the natural flow regime, campgrounds and dispersed camping have all had impacts on Hyalite Creek and associated riparian areas in a variety of ways and degree. Most notably, the large woody debris recruitment to Hyalite Creek has been reduced in areas immediately adjacent to Langohr Campground and Hyalite Canyon Road where hazard and firewood trees have been removed since this road was constructed. Removal of large woody debris and the operation of the splash dam have adversely affected both the quantity and quality of pool habitat simplifying the habitat. Past restoration activities along this segment of Hyalite Creek have concentrated on increasing both the quantity and quality of pool habitat through the placement of large woody debris and/or boulders. Because of the high gradient nature of Hyalite Creek and high summer flow releases from Middle Creek Dam, fine sediments appear not to accumulate to the point of having adverse affects on the local fishery above the Forest boundary. Low flow conditions below the Forest boundary most likely block fish migration below the intake during the summer months. Within the last year, the City of Bozeman has placed a fish ladder at the diversion structure to the water intake to allow upstream fish passage.

Applicable Laws, Regulations, Policy, and Forest Direction

Presidential Executive Order 12962

Presidential Executive Order 12962, signed June 7, 1995, furthered the purpose of the Fish and Wildlife Act of 1956, the National Environmental Policy Act of 1969, and the Fish and Wildlife Coordination Act, seeking to conserve, restore, and enhance aquatic systems to provide for increased recreational fishing opportunities nationwide. This order directs Federal agencies to "improve the quantity, function, sustainable productivity, and distribution of aquatic resources for increased recreational fishing opportunity by evaluating the effects of Federally funded, permitted, or authorized actions on aquatic systems and recreational fisheries and document those effects relative to the purpose of this order."

Sensitive Species

Sensitive species are those plant and animal species identified by a Regional Forester for which population viability is a concern as evidenced by a significant current or predicted downward trend in population numbers or density, and significant current or downward trends in habitat capability that would reduce a species' existing distribution (Forest Service Manual (FSM) 2670.5).

The objective of the Sensitive Species Policy is to maintain viable populations of all native and desired non-native vertebrate species in habitats distributed throughout their geographic range on National Forest System lands. The sensitive species program is intended to be pro-active by identifying potentially vulnerable species and taking positive action to prevent declines that will result in listing under the Endangered Species Act.

As part of the National Environmental Policy Act (NEPA) decision-making process, proposed Forest Service programs or activities are to be reviewed to determine how an action will affect any sensitive species (FSM 2670.32). The goal should be to avoid or minimize impacts to sensitive species. If impacts cannot be avoided, the degree of potential adverse effects on the species (and habitat) within the project area and for the species throughout its range must be disclosed. A given project can be approved even if it may adversely affect a sensitive species, but it must not result in the loss of species viability or create significant trends toward federal listing.

Presently, westslope cutthroat trout, Yellowstone cutthroat trout, western toad, northern leopard frog, and fluvial (river dwelling) Arctic grayling are included on the current Region 1 Sensitive Species list (USFS 2004). The proposed Region 1 Sensitive Species list which is due out in late-winter 2011 will include western pearlshell mussel (*Margaritefera falcata*) and eliminate fluvial Arctic grayling on the Gallatin National Forest. The effects of the proposed activities on western toad and northern leopard frog are included in a Biological Evaluation (BE) in the project file. Western pearlshell mussel will be added to the list for all National Forests within their native range. Yellowstone cutthroat trout in Hyalite Reservoir are not native to the analysis area. As a result, Yellowstone cutthroat trout are not classified as sensitive species within the analysis area. To insure the right species are evaluated, the BE within this report will address all species included both on the current and proposed lists including: westslope cutthroat trout, fluvial Arctic grayling, and western pearlshell mussels.

Implementation Strategy for the 1999 Westslope Cutthroat Trout Conservation Agreement/MOU within the Upper Missouri River Basin

The Memorandum of Understanding and Conservation Agreement (MOUCA) for Westslope Cutthroat Trout in Montana includes as objectives: 1) protecting all pure and slightly introgressed (90% or greater purity) westslope cutthroat trout populations; and, 2) ensuring the long-term persistence of westslope cutthroat within their native range. In a letter from Bradley Powell (Regional Forester) to Upper Missouri River Basin Forest Supervisors (January 16, 2002), he articulates how forests are to implement the MOUCA. In Section II: Implementation Strategy (Part A) states “When the above conditions (1-3) are met, FS Biological Evaluations (BE) FSM 2670 and BLM Sensitive Species Assessments (6840) Manual prepared for new activities in a WCT watershed should, in most cases, conclude that there will be a beneficial effect or no effect to the WCT population or its habitat” (Powell 2002). These three conditions include: 1) Provide watersheds supporting conservation populations of WCT with the level of protection necessary to ensure their long-term persistence; 2) Defer any new federal land management action if it cannot be modified to prevent un-acceptable aquatic/riparian habitat degradation; and, 3) Where appropriate data are available, “high quality” habitat will be defined as habitat which is at 90% or greater of its inherent capability or potential. Later, the Implementation Strategy states “Actions that result in short-term impacts but are designed to obtain beneficial long-term effects to WCT should be judged against the criteria and optimum condition values characteristic of high quality habitat (Attachment One)."

Eastern brook trout and rainbow trout are frequently cited as a significant contributing factor to the decline of westslope cutthroat trout (Liknes 1984, Liknes and Graham 1988, Rieman and Apperson 1989, and Shepard 2010). Hybridization is the primary cause for the reduction of genetically pure populations of westslope cutthroat (Allendorf and Leary 1988). Fausch (1988, 1989) concluded that the persistence of westslope cutthroat trout is jeopardized in streams also supporting brook trout and brown trout (Salmo trutta). These scenarios have and continue to play out resulting in fewer cutthroat trout populations throughout their native range.

The Memorandum of Understanding and Conservation Agreement for Westslope Cutthroat Trout and Yellowstone Cutthroat trout in Montana (MFWP 2007) includes the following objective to "maintain, secure, and/or enhance all cutthroat trout populations as conservation populations, especially the genetically pure components." This agreement states that "Introgressed conservation populations will typically be < 10% introgressed." To align with this objective and definition, it is the interpretation of Region 1 of the U.S. Forest Service that cutthroat trout with 90% or greater genetic purity are considered as a sensitive species.

If a population or stream system has been tested and found to be significantly introgressed (> 10%), it is not considered a conservation population or a sensitive species. The only conservation populations within the project area are Leverich Creek and Wildhorse Creek. There are no known cases within the historic distribution of westslope cutthroat trout where populations have recovered on their own without management actions after being invaded or eliminated by rainbow trout and eastern brook trout. Genetic re-testing and population surveys of previously identified genetically altered populations would yield the same or worse results.

Forest Plan Direction

<u>Forest-Wide:</u>

Fish and Wildlife A-14: The Forest will be managed to maintain and, where feasible, improve fish habitat capacity to achieve cooperative goals with Montana Fish, Wildlife and Parks and to comply with State water quality standards.

Management Area 7 (Riparian Areas)

Fish and Wildlife 2: Provide for optimum water temperatures for cold-water fish species.

Fish and Wildlife 3: Maintain minimum instream flows.

Fish and Wildlife 4: Maintain suitable habitats for those species of birds, mammals, and fish that are totally or partially dependent upon riparian areas for their existence.

<u>Management Area direction</u> for this proposed action includes: 1) emphasizing logging practices which minimize soil disturbance; and 2) avoid using equipment which causes excessive soil compaction and displacement. The State of Montana requires Best Management Practices implementation for all activities to ensure compliance with water quality standards and to protect fish and amphibian habitats.

The goals for Management Area 7 outlined in the Forest Plan have been further defined by an agreement with the Madison-Gallatin Chapter of Trout Unlimited (MGTU) in 1990 (Gallatin National Forest 1990). Vegetative manipulation within riparian areas will occur only for the purpose of meeting riparian dependent resource objectives. Riparian areas are defined as the land and vegetation for approximately 100 feet from the edge of a perennial stream. Fuel treatments within 100 feet of streams were coordinated with MGTU to achieve riparian dependent resource objectives. This coordination meets the intent of the agreement that is binding only with the MGTU organization. (MGTU 2007)

Forest Travel Plan Direction

The following standards have been incorporated as part of the Gallatin National Forest Travel Management Plan signed December 18, 2006 (GNF 2006). In the past, the sediment standard consisted of four categories of streams. Fishless headwater streams (i.e., Category C and D streams) were managed at a level below what Montana Department of Environmental Quality (MDEQ) considers as maintaining beneficial uses. This new direction formalizes these two standards for sediment.

Standard E-4: Water, Fisheries, and Aquatic Life. In watersheds with streams currently at or above fish habitat management objectives, proposals for road and trail construction, reconstruction and maintenance will be designed to not exceed annual sediment delivery levels in excess of those in Table 2. Sixth-code Hydrologic Unit Codes (HUCs) are the analysis unit for sediment delivery (and other habitat parameters), except where a sixth code HUC artificially bisects a watershed and is therefore inadequate for analysis of impacts to aquatic habitat and aquatic organism meta-populations. In such cases, appropriate larger units will be analyzed (e.g. 5th code HUCs). Within the analysis unit, sediment delivery values in Table 2 will serve as guidelines; however, sediment delivery values denoted in individual 7th code HUCs may temporarily exceed sediment delivery rates denoted in Table 2, in the following circumstances:

1. The HUC does not contain a fragmented sensitive or MIS fish population;

2. The majority of HUCs in the analysis unit remain within sediment delivery values listed in Table 2;

3. Other core stream habitat (e.g. pool frequency, pool quality) or biotic (e.g. macro-invertebrates, fish populations) parameters within the HUC do not indicate impairment as defined by Montana Department of Environmental Quality (MDEQ); and

4. Sediment delivery levels will return to values listed in Table 2 within 5 years of project completion.

Class A streams are those streams supporting a sensitive fish species or provide spawning or rearing habitat to the Gallatin, Madison, or Yellowstone Rivers, or Hebgen Lake. Class A streams are to be managed at a level which provides at least 90 percent of their inherent fish habitat capability. Class B streams are those streams that are regionally or locally significant and support both a quantity (substantial quantities of harvestable fish) and quality (numerous fish over 10 inches in length) fish populations. Class C streams are characterized as having limited local significance and provide a diversity of lower quality dispersed fishing opportunity.

Table 2. Substrate sediment and sediment delivery by Forest stream category.

Category	Management Objective (% of reference*)	% Fine Substrate Sediment (<6.3mm)	Annual % > Reference** Sediment Delivery
A Sensitive Species and/or Blue Ribbon fisheries	90%	0 – 26 %	30%
B All other streams (formerly Classes B, C, D)	75%	0 – 30 %	50%

*% of reference = % similarity to mean reference condition; reference conditions range.

**Reference = observed relationship between substrate % fines and modeled sediment delivery in reference (fully functioning) GNF watersheds.

Bozeman and Hyalite creeks are tributaries to the East Gallatin River which is a tributary to the Gallatin River. Lower Bozeman Creek near the trailhead and Hyalite Creek from the Forest boundary upstream to Middle Creek Dam are heavily fished during the summer months. Because of these reasons, both of these streams are considered Class A streams. Leverich Creek is also considered a Class A stream because of the presence of westslope cutthroat trout.

Management Indicator Species (MIS) are those species whose habitat is most likely to be affected by management practices thereby serving as indicators of habitat quality. The Gallatin National Forest Plan directs that habitat is provided for identified management indicator species and those native indigenous species that use special or unique habitats. All wild trout have been identified as MIS in the Gallatin National Forest Plan on page II-19 (GNF 1987).

Standard E-5: Water, Fisheries, and Aquatic Life. Proposed roads and trails shall not be located in the floodplains of rivers and streams or in wetlands except where necessary to cross a stream or wetland with appropriate permits.

Standard E-6: Water, Fisheries, and Aquatic Life. Stream crossing facilities for proposed roads and trails shall allow for passage of aquatic organisms, by avoiding stream channel constriction or alteration of the flow pattern, except where passage restriction is desired to isolate genetically pure cutthroat trout populations from exposure to hybridization or competition by non-native salmonids.

Standard E-7: Water, Fisheries, and Aquatic Life. Road materials should not be side-cast into stream or wetlands.

A species group including all redd (or intra-streambed nests) spawning wild trout was selected and referenced in the Gallatin National Forest Plan (GNF 1987) as Management Indicator Species (MIS) on page II-19. This species group was selected as Management Indicator Species because it has been shown that spawning habitat can be affected by forest management activities thereby serving as indicators of habitat quality. Overall, wild redd spawning trout are widespread and common or abundant on the Gallatin National Forest within the Yellowstone and upper Missouri River drainages (GNF 2010). These factors combine to indicate that, in general, aquatic habitats are being maintained sufficient to support coldwater fisheries as required by the Clean Water Act. Sediment related impacts on this species group are discussed under each alternative.

Environmental Effects

The following analysis describes anticipated direct, indirect and cumulative effects to fish populations and habitat primarily as a result of sediment delivery. These effects are described for each alternative. The analysis characterizes the direction of effect, the magnitude of the anticipated effect and the duration of the effect.

Direct effects are defined as those effects that occur at the same time and place as the triggering action. For fisheries, it is those actions that result in immediate mortality to fish such as fuel spills, acute sediment delivery, etc. Indirect effects are defined as those effects that occur later in time and distance from the triggering action. For fisheries, it is those actions that affect fish populations and habitat as a result of chronic sediment sources, reduction in stream shading, reduction in large woody debris recruitment, etc. Because this proposal contains no riparian timber harvest, landings, or major stream crossings, most if not all of the effects, would be indirect in nature.

Methodology for Analysis

Potential effects of the Bozeman Municipal Watershed Fuels Reduction Project on fish and fish habitats were analyzed by a quantitative assessment. This assessment includes evaluating the combined effects of all treatments and associated activities including log hauling by alternative on sediment delivery rates on salmonid spawning and rearing habitat. Percent over Natural Sediment Delivery (tons/year) was used as one of the three indicators to make comparisons between the alternatives.

Natural, existing and post-project sediment delivery (or yield) rates were calculated by the Gallatin National Forest Hydrologist (Story, 2010) for all alternatives using a modification of the R1/R4 sediment model (Cline et al. 1981). The actual effects of additional delivery of fine sediment on salmonid spawning and rearing habitat would be dependent on precipitation, stream flow, how quickly exposed soil is stabilized, and how the sediment is delivered to, and routed within the stream during project activities. The effects of this additional sediment delivery on salmonid spawning and rearing habitat was estimated for all alternatives using a modification of the Fish/Sed model (Stowell et al. 1983) which estimates the change in substrate composition resulting from changes in sediment delivery rates. This modification more accurately reflects sediment routing relationships of geologies found on the Gallatin National Forest.

This model assumes a linear relationship between estimated percent sediment yield over natural (from the R1/R4 sediment model) and fine sediment accumulation in spawning gravels, the latter value calibrated from actual data from Gallatin National Forest streams. The predictive regression equation is $\{y= s + 0.24(x)\}$, where x is the predicted incremental increase in percent of sediment yield over natural on an annual basis, y is the predicted percent of fine sediment less than 6.35mm deposited in the spawning gravels, s is the existing percent of fine sediment in the substrate and 0.24 is the slope of the relationship. The coefficient of 0.24 best reflects this relationship from an annual perspective. This equation was developed by regressing measured instream sediment concentrations with predicted increases in sediment yield from the R1/R4 sediment model. Application of this model provides an estimate of incremental change in fine sediment deposition in spawning gravels associated with predicted sediment yield changes. The estimated sediment concentrations are then compared to sediment/survival curves developed for cutthroat trout embryos (Irving and Bjornn 1984).

The R1/R4 sediment delivery and sediment/routing models are very simplified approximations of complex natural processes that affect sediment production and fish embryo survival, due to the models inability to predict all aspects of natural variation associated with sediment delivery and routing. Because of this, resulting values are not considered definitive or absolute; rather they are used only to evaluate the relative magnitude and direction of incremental change in spawning habitat and as a means to make relative comparisons between alternatives.

Hydrologic effects or changes in hydrologic processes such as changes in the timing and intensity of spring runoff are addressed in the hydrology section of the water analysis (Story 2010).

The SIMPPLE model was run specifically for the Leverich Creek to portray the potential watershed benefits resulting from the proposed activities. See FEIS 3-216 for the methodology used to run the SIMPPLE model. Model output was used to compare the weighted probability that a stand replacing and mixed severity fire will occur within the Leverich Creek drainage at 10 to 20 years from now. This was one of the four indicators used to describe both the positive and negative effects of the proposed alternatives on aquatic species.

Spatial Boundary

Aquatic environments in forested ecosystems are known to be heavily influenced by the physical and biological processes within the watershed as a whole (Vannote et al. 1980). For this reason the analysis area for fish will encompass the entire Bozeman Creek watershed above the water intake, Hyalite Creek watershed above the water intake and the smaller Leverich Creek watershed above the Forest boundary (Figure 3). The diversion structures at both water intakes function as a sediment trap, which are cleaned out periodically. Leverich Creek is collected by a series of cross ditches below the mouth of the canyon. Project generated sediment from Leverich Creek would most likely not reach Bozeman Creek. Treatment units and associated activities within the Hodgman Canyon and Cottonwood Creek watersheds will not be analyzed for the following reasons.

Sediment from existing and proposed fuels reduction activities within the Hodgman Canyon would reach the intermittent stream course in the bottom of Hodgman Canyon. Upper Hodgman Canyon watershed, above the National Forest boundary, lies above several cross ditches which would collect project generated sediment before it would ever reach Hyalite Creek. As a result, there would be no direct, indirect or cumulative effects on fish and fish habitat along Hyalite Creek as a result of proposed activities within the Hodgman Canyon drainage. See Cumulative Effects Check List in project file for water and fish.

Proposed treatment units within the Cottonwood Creek watershed are located high on the hydrologic divide separating the Cottonwood and Hyalite Creek drainages. As a result, the likelihood of direct, indirect and cumulative effects on fish and fish habitat in Cottonwood Creek would be extremely low. See Cumulative Effects Check List in project file for water and fish.

Temporal Boundary

The fisheries analysis is based mostly on the sediment modeling data provided by the Forest hydrologist (Story, 2010). For the fisheries analysis, the temporal bounds were set from 1980 to 2017. The earliest date was selected around the approximate year when the last road(s) were constructed within the Hyalite and Bozeman Creek watersheds. The later date was extended one year beyond when the sediment modeling showed any increase in sediment delivery for any of the six alternatives. Sediment transport in streams is highly variable and is influenced by several factors including channel type, amount of sediment, length of time sediment input occurs, flow regime, substrate composition and geology.

Generally speaking, climate change presents a threat to aquatic habitat with projected effects on water temperature and quantity. Recent warming has already driven significant changes in the hydroclimate, with a shift towards more rainfall and less snow in the western U.S. (Knowles et al. 2006). Likewise, the peak of spring snowmelt has been two weeks earlier in recent years, and this trend is anticipated to continue (Stewart et al. 2004). Probable effects of climate change in the western U.S. will be increased water shortages and warmer water temperatures. These conditions may further restrict distribution of cold water dependent species such as cutthroat trout (Williams et al. 2009) while increasing distribution of species more tolerant of warmer temperatures such as brook trout and brown trout (Rahel et al. 2008). In addition, changes in timing of spring runoff and temperature may alter spawning cues that have maintained temporal segregation of native and nonnative species. However, in areas of topographic variability such as those within the project area, local responses are highly variable (based on flow regimes, topography, and geology), and current climate models cannot reasonably predict responses at a practical scale. The past and present effects of climate change on project area fish habitat and populations are reflected in the existing condition. Within the temporal bounds of this analysis, ongoing effects of climate change are not expected to significantly alter baseline habitat conditions.

Direct and Indirect Effects of Alternative 1 (No Action Alternative)

For the No Action Alternative, there would be no fuel reduction activities along streams and/or associated riparian areas within the project area. Thus, there would be no potential to impact streams, riparian areas and/or fish habitat. This alternative would result in no effect beyond existing conditions. However, the potential for high intensity and high severity fires along project area streams exists and would increase over time.

Fish populations have evolved with wildfire and the ecological processes associated with them. Wildfires play an important role in maintaining spatial and structural diversity, habitat complexity and nutrient cycling. However, when fire size, frequency, intensity or severity are outside the range of natural variability (i.e., fuel loading is excessive) there is a potential for watersheds to burn beyond their adaptive limits. With large-scale high severity fires, there is a potential threat to watershed integrity and associated fish species persistence.

Existing fuel loads are high throughout the project area (FEIS, p. 1-7), including riparian corridors. Treatments associated with the proposed action alternatives are intended to reduce burn intensity and severity throughout the lower portion of these drainages. Reducing the intensity and severity of potential wildfires along the lower portions of these drainages could have beneficial effects to riparian integrity and fish habitat quality. Those benefits would not be realized for the No Action Alternative. Because of the short distance of occupied habitat and isolation, a severe wildfire could eliminate this population.

Unless Management Indicator Species (all trout) and Sensitive Species (westslope cutthroat trout) populations and associated habitat are impacted by wildfires, these populations and associated habitat quality would remain the same or improve under the No Action Alternative as related to sediment delivery. Activities listed as reasonably foreseeable actions (primarily road and trail decommissioning) would result in these improvements. Reasonably foreseeable actions are listed in the cumulative effects checklist in the project file and more recent actions are listed in the Other Related Efforts section at the beginning of the SFEIS. Percent fine sediments are expected to decrease as a result of recent trail and road decommissioning (Table 3). These reductions will be beneficial to management indicator and sensitive species inhabiting these streams. Populations of management indicator species are expected to remain viable.

Westslope Cutthroat Trout Viability

The appropriate scale for a viability analysis should focus on the “biological” population that management activities could affect (Ruggiero et al. 1994). A biological population is a cluster of individuals with a high probability of mating with one another compared to the probability of mating with members of other populations. An in-depth viability analysis can be a complex process involving the integration of a wide range of information including: life history attributes and ecological needs, habitat needs by life-stage, habitat condition, and population abundance. In simple terms, viability is about birth, death, immigration, and emigration rates and how environmental and ecological factors affect those rates over time. To avoid extinction, a population must be able to persist through deterministic and stochastic environmental and ecological change. To theoretically determine the effects of a specific management action on persistence (or viability) of the population through time, Ruggiero et al. (1994) recommend addressing four primary questions.

(1) Has habitat amount or condition been changed over time and space relative to the extent of the population of interest?

Historically, Leverich Creek was connected to Bozeman (or Sourdough) Creek below the Forest boundary. Because of dewatering, cross ditches, dams and small reservoirs located downstream on private land, it is believed that the connection to the nearest neighbor population has been severed. Immigration of new individuals has been blocked. Because of these structures, it appears that emigrating individuals could be lost because of downstream barriers.

The core of the Leverich Creek westslope cutthroat trout population was constrained to 0.61 miles between a partial migration barrier just above the Forest boundary and an upstream high gradient bedrock chute. Below the partial barrier, few cutthroat trout existed previous to 2007 most likely as a result of the brook trout dominance. An artificial migration barrier will be constructed by Montana Fish Wildlife and Parks in 2011 below the Forest boundary on private land. Subsequently, brook trout will be removed extending the population core from 0.61 miles to 1.3 miles. Previous efforts to remove brook trout prior to the installation of the new culvert have resulted in a steady increase in westslope cutthroat trout abundance.

Most of the roads within the Leverich Creek drainage are located within the headwaters and ridge tops with the exception of the road up the bottom to the trailhead. This road parallels Leverich Creek for about 1.0 mile from the mouth of the canyon located on private land upstream to the trailhead located on the Forest. With the exception of the two stream crossings (culverts), dense vegetation exists between the road and Leverich Creek. From the trailhead, one old road and two trails radiate. The trails and road were decommissioned in 2009 and are presently well vegetated. A new trail was constructed away from the left hand fork of Leverich Creek eliminating several creek crossings. In addition, timber has been removed immediately adjacent to the right fork within two clearcuts that were laid out to the streams edge. All of these activities have delivered sediment to Leverich Creek impacting the reproductive success of cutthroat trout and aquatic invertebrate production. Small pockets of clean spawning gravel presently exist along the ½ mile reach of occupied habitat.

Because of paralleling roads and adjacent clearcuts, the recruitment of large woody debris appear to have been reduced immediately adjacent to these activities. The quantity of deeper overwintering pools appears to have been reduced.

(2) What is known about the ecology of the species under investigation, and how does this knowledge relate to the current management situation?

Within the U.S., westslope cutthroat trout presently occupy 59% of their historically occupied habitat. Westslope cutthroat trout with no evidence of genetic introgression currently occupy 10% (or 3,400 miles) of currently occupied habitat (Shepard et al. 2003).

Within the upper Missouri River drainage, westslope cutthroat trout presently occupy 5.5% of their historically occupied habitat. Westslope cutthroat trout with no evidence of genetic introgression currently occupied 3.0% (or 519.4 miles) of currently occupied habitat (Shepard et al. 2003). Within the Gallatin River drainage, only three scattered populations of genetically pure westslope cutthroat trout still exist occupying less than 10 miles of stream.

The core population is located in a 0.61 mile reach of stream upstream of a partial barrier that appears to be slowing the expansion of eastern brook trout. Based on two population estimates, it is estimated that 235 westslope cutthroat trout greater than 75 mm exist above this partial barrier. With the exception of one large 240 mm adult, all other adult westslope cutthroat trout were less than 177 mm. If this size range is indicative of the entire population of adults, fecundity is expected to be less than 250 eggs per female (Nelson 2007, unpublished data).

Eastern brook trout also occupy Leverich Creek. Throughout the native range of westslope cutthroat trout in the upper Missouri River basin, it has been shown that non-native eastern brook trout have displaced native westslope cutthroat trout in numerous streams. The mechanism or mechanisms by which brook trout displace native cutthroat trout is not well understood. Displacement is most likely a result of the combination of several mechanisms such as competition for food and space and predation. The bottom line is that non-native brook trout can and will displace native cutthroat trout. There is no reason to believe that cutthroat trout displacement is not occurring within Leverich Creek even though the brook trout are at low density.

(3) How will recruitment and death rates be directly (e.g., habitat loss) and indirectly (e.g., increasing probability that stochastic events will affect the population) affected by management?

Under the No Action Alternative, birth rates (survival of eggs to fry) are expected to improve by 2.6% as a result of the implementation of recent road and trail decommissioning directed at reducing sediment delivery. This also assumes that stand replacing and mixed severity wildfires would not burn through the drainage.

Steep canyons, dense valley bottom coniferous vegetation, and a north-south valley alignment are factors that could result in a high severity/high intensity wildfire burning through the Leverich Creek drainage resulting in negative impacts to this small isolated population of genetically pure westslope cutthroat trout. Considering these topographical factors and other pertinent data, it was determined that 71% of the Leverich Creek drainage is presently at high risk from fire (Project Map, Project File). Also, the weighted probability that a stand replacing and mixed severity fire would occur within the Leverich Creek drainage at 10 and 20 years was determined to be 33.9% (Novak, 2007). This compares to 6.2% and 8.3% for the Bozeman Creek and Hyalite Creek drainages, respectively.

Negative impacts could come from a variety of different directions such as changes to water temperature (directly from the fire or from reduced stream shading), increased sediment delivery, increased bedload movement, reduced channel stability, etc. For example, a fast moving canopy fire in a similar sized drainage in Idaho was shown to raise the base water temperature from 12.8°C to 22.2°C in matter of a few minutes (Gamett, 2002). In some cases, fast moving fire fronts have resulted in complete fish kills in small headwater streams. High precipitation events within small extensively burned drainages can also cause bedload movement and/or debris torrents resulting in the simplification of instream habitat (Sestrich 2005, Rieman et al. 1997). Watersheds, stream channels and fish populations have the ability to recover from all such disturbances over time. Because of the isolation of this small population of cutthroat trout, such fire-related disturbances could play a major role in causing this population to go extinct. Even though the watershed and stream channel would recover over time, the population would not recover because of the lack of connectivity with nearest neighbors.

(4) Given all available information, it is possible to make an informed judgment on the effects of the management action on survival of individuals and persistence of the population?

With or without natural or human-caused disturbances, the local population of westslope cutthroat trout in Leverich Creek is at extreme risk of extinction (Rieman et al. 1993) for the reasons discussed above. Because of the isolation and limited habitat (i.e., small stream size and length of occupied habitat), the extinction risk will always remain extreme unless this population is reconnected with other nearby populations. Both population and habitat management actions will be required to maintain this population at or above the existing level. These actions include removing non-native brook trout, increasing the frequency of deeper overwintering pools and reducing sediment input.

Of the four previous questions, only question three addresses the impacts from the proposed management. As a result, only question three will be discussed under each of the five Action Alternatives.

Cumulative Effects of Alternative 1

The R1/R4 sediment modeling was run for Alternative 1 in a cumulative mode accounting for all roads (existing and previously decommissioned), previous timber harvest, previous prescribed and wild fires, and residential and recreational developments in the Bozeman, Hyalite and Leverich watersheds (Story, 2010). Projected changes in sediment yield or sediment delivery from these model runs are displayed in the Water Quality Section of this document.

Of the listed reasonably foreseeable activities in the water and fish cumulative effects check list (project file), the only projects that would change sediment delivery include: decommissioning and stabilization of roads and trails identified in the Gallatin National Forest Travel Plan FEIS (2006), reconstruction of FS Trail 435 (completed in 2008), installation of boulder clusters to improve fish habitat in Hyalite Creek (completed in 2007), reconstruction of three fishing platforms along Hyalite Creek (completed in 2008), and installation of log structures along Leverich Creek to increase overwintering habitat for westslope cutthroat trout (projected for 2013). There would be a small, but short-term increase in sediment delivery associated with these projects along Hyalite Creek and Leverich Creek. Disturbed areas would be stabilized immediately upon project completion to prevent long-term sediment delivery. Sediment delivery from these projects is expected to be immeasurable at the water intakes or Forest boundary.

The decommissioning and stabilization of trails and project roads listed in the Gallatin National Forest Travel Plan FEIS (2006) would occur within all three analysis watersheds: Hyalite Creek, Bozeman Creek and Leverich Creek. There are 2.5 miles of project roads within the Leverich Creek analysis area, 7.7 miles within the Bozeman Creek analysis area, and 29.5 miles within the Hyalite Creek analysis area. The majority of the roads scheduled to be decommissioned within the Hyalite and Leverich Creek drainages were decommissioned in 2009 and 2010 with the remainder being scheduled to be decommissioned upon project completion. Decommissioning consist of pulling cross drain culverts and reestablishing drainage patterns, seeding and slashing all disturbed areas near water courses, placing woody debris across the road prism, installation of cross ditches (or erosion ditches) and recontouring short segment of the road prism to prevent future motorized travel. Decommissioning roads often results in short-term increases in sediment delivery, sometimes measurable at downstream quantification points. In the long-term, sediment delivery from these routes would be significantly reduced.

Conclusions

Assuming no high severity/high intensity fires occur throughout the analysis areas, the Percent over Natural (or Reference) Sediment Delivery and Annual Percent Fines in Substrate would remain the same in Bozeman Creek whereas it would drop in both Hyalite Creek and Leverich Creek as a result of recent road decommissioning. The three analysis areas presently meet the Gallatin National Forest Travel Plan standard for Percent over Natural Sediment Delivery. Alternative 1 would have a positive effect on Management Indicator Species (wild trout) and Sensitive Species (westslope cutthroat trout) within the Hyalite and Leverich Creek drainages. The intent of the Implementation Strategy for 1999 Memorandum of Understanding and Conservation Agreement (MOUCA) for Westslope Cutthroat Trout in Montana would be met.

Table 3. Summary of fisheries indicators for the No Action Alternative (Alternative 1).

Drainage	Meets Sediment Standard for Percent Over Natural Sediment Delivery for Class A Streams	Maximum Projected Change in Percent Fine Sediment	Minimum Projected Change in Percent Fine Sediment.
Bozeman	Yes	0.0	0.0
Hyalite	Yes	0.0	-0.5
Leverich *	Yes	0.0	-1.0

This Alternative meets the intent of the MOUCA for Westslope Cutthroat Trout in Leverich drainage. Westslope cutthroat trout do not inhabit these analysis areas downstream of proposed treatment units in Bozeman and Hyalite Creeks.

The weighted probability of a stand replacing and mixed severity fire within Leverich Drainage in the next 10-20 years is 33.9%.

* = assuming the watershed remains intact without any high severity or high intensity fires.

The No Action Alternative is consistent with all Applicable Laws, Regulations, Policy and Forest Direction. There would be no irreversible or irretrievable commitment of aquatic or fisheries resources.

Direct and Indirect Effects of Alternative 2

No riparian timber harvest, landings, and/or major stream crossings would occur under Alternative 2. Riparian areas adjacent to perennial water bodies would be buffered to prevent fire from burning within these areas. Broadcast burning would be implemented in a manner to prevent head fires within riparian areas not associated with perennial water bodies. Broadcast burns within these riparian areas would be allowed to back down and creep around. All proposed temporary roads are located away from major streams. Several of the proposed temporary roads would cross headwater drainages which may or may not be wet. No proposed temporary roads would be constructed through areas of high mass wasting hazard (Keck, 2010). As a result, no direct effects are expected to occur under Alternative 2.

Construction of temporary roads within the Hyalite Creek watershed (2.5 miles) together with the treatment of 1,092 acres is projected to increase the sediment delivery rate above the existing level of 5.8% over natural. Coupled with the recent road decommissioning in the Hyalite Creek analysis area, there would be a projected reduction of 2.2% over natural to 3.6%. This equates to a projected decrease of 0.5% in the percent of fine sediment in spawning substrate in 2017 (Table 4).

The treatment of 2,264 acres within the Bozeman Creek watershed is projected to increase the sediment delivery rate from 3.4% to 5.8% over natural. No temporary roads would be constructed within the Bozeman Creek watershed on NFS lands. This equates to a projected maximum annual increase of 0.6% in the percent of fine sediment in spawning substrate. These sediment figures also include the treatment of City of Bozeman lands.

The stream channel types along both Hyalite and Bozeman creeks have a moderate capacity to carry and flush sediment. Together with the low predicted increases in percent fines in spawning substrate, changes in pool habitat quality (i.e., primarily filling of pools) along Bozeman and Hyalite creeks are expected to be minimal and short-term, if any at all.

The construction of temporary roads within the Leverich Creek watershed (0.8 miles) together with the treatment of 432 acres are projected to increase the sediment delivery rate from 8.4% to 33.2% over natural. This equates to a maximum annual increase of 6.0% in the percent of fine sediment in spawning substrate.

Projected changes in percent fine sediment would have the following biological effect on trout species that occupy these streams. Percent egg-to-fry survival for westslope cutthroat trout in Leverich Creek would be reduced by 15.3% down from 51.4% (Irving and Bjornn, 1984). This compares to a 1.4% reduction (down from 67.5%) in egg-to-fry survival for rainbow trout in Bozeman Creek and 0.5% increase in egg-to-fry survival in Hyalite Creek.

Westslope Cutthroat Trout Viability

See westslope cutthroat trout viability assessment under Alternative 1 for answers to questions 1, 2, and 4.

(3) How will recruitment and death rates be directly (e.g., habitat loss) and indirectly (e.g., increasing probability that stochastic events will affect the population) affected by management?

The implementation of Alternative 2 would reduce the probability of stand replacing and mixed severity fire at 10 to 20 years within the Leverich Creek drainage by 56% compared to Alternative 1 (Novak 2007). After all treatments are completed, timber stands within the Leverich Creek drainages would have a weighted probability of stand replacing and mixed severity fire at 10 to 20 years of 15.0% as compared to 33.9% under Alternative 1. Because the Leverich Creek westslope cutthroat trout population is no longer connected to nearby populations, potential wildfire-related impacts associated with changes to water temperature regimes, bedload movement, stream channel stability, stream flow, sediment delivery, etc. could be major. There are too many naturally occurring variables to be able to adequately predict the kind and severity of these impacts.

The implementation of that portion of Alternative 2 within the Leverich Creek drainage is expected to increase fine sediment in spawning habitat by 6.0%. This anticipated result would most likely have adverse effects on the quality of spawning habitat, quality of pool habitat, and macroinvertebrate populations and would further increase the rate of extinction of this small isolated population of westslope cutthroat trout. After all project generated sediments are flushed from the Leverich Creek watershed resulting from the proposed fuels reduction project, the sediment level in Leverich Creek would be reduced by 1.0% as a result of the implementation of recent trail and road decommissioning designed to reduce sediment.

Cumulative Effects of Alternative 2

The list of reasonably foreseeable actions would remain the same for all alternatives. The only difference in cumulative effects is those additive project related direct and indirect effects displayed by alternative. See Cumulative Effects check list in the project file.

Conclusions

The implementation of Alternative 2 would meet the Gallatin National Forest Travel Plan 30% standard for Percent Over Natural Sediment Delivery for the Hyalite Creek and Bozeman Creek. Alternative 2 would have a small short-term negative effect on Management Indicator Species (wild trout) within the Bozeman Creek analysis area. Alternative 2 coupled with the recent road decommissioning within the Hyalite Creek analysis area would have beneficial effects on Management Indicator Species. Populations of Management Indicator Species are expected to remain viable within entire Gallatin National Forest planning area (GNF 2010).

The projected increase in sediment delivery under Alternative 2 for Leverich Creek analysis area would exceed the Gallatin National Forest Travel Plan 30% standard. The probability of stand replacing fire and mixed severity fire within the Leverich Creek drainage would be reduced from 33.9% to 15%. It is expected that the portion of Alternative 2 within the Leverich Creek analysis area would not meet the intent of the Implementation Strategy for 1999 Memorandum of Understanding and Conservation Agreement (MOUCA) for Westslope Cutthroat Trout in Montana as a result of increased sediment projections.

Table 4. Summary of fisheries indicators for Alternative 2.

Watershed	**Meets Sediment Standard for Percent Over Natural Sediment Delivery for Class A Streams**	**Maximum Projected Change in Percent Fine Sediment**	**Minimum Projected Change in Percent Fine Sediment.**
Bozeman	Yes	+0.6	0.0
Hyalite	Yes	-0.2	-0.5
Leverich *	No	+6.0	-1.0

This Alternative does not meet the intent of the MOUCA for Westslope Cutthroat Trout in Leverich drainage. Westslope cutthroat trout do not inhabit these analysis areas downstream of proposed treatment units in Bozeman and Hyalite Creeks.

The weighted probability of a stand replacing and mixed severity fire within Leverich Drainage in the next 10-20 years is 15%.

Alternative 2 is not consistent with all Applicable Laws, Regulations, Policy and Forest Direction as they pertain to westslope cutthroat trout within the Leverich Creek analysis area. Westslope cutthroat trout could always be restocked back into Leverich Creek once the habitat recovers from the proposed disturbance, but the local adaptation and associated genetic diversity that this local population brings to the upper Missouri River basin would be lost forever. If this were to occur, there would be an irreversible or irretrievable commitment of resources.

Direct and Indirect Effects of Alternative 3

No riparian timber harvest, landings, and/or major stream crossings would occur under Alternative 3. Riparian areas adjacent to perennial water bodies would be buffered to prevent fire from burning within these areas. Broadcast burns within these riparian areas would be allowed to back down and creep around. Broadcast burning would be implemented in a manner that would prevent head fires within riparian areas. Although, broadcast burns would be allowed to back down into riparian areas and creep around. All proposed temporary roads are located away from major streams. Several of the proposed temporary roads would cross headwater drainages which may or may not be wet. A small segment (< 0.25 mi.) of proposed temporary roads within the Hyalite Creek watershed is located within an area of high mass wasting hazard (Keck 2010). This segment of road is located near the ridgeline away from any stream courses. In the event there was a road prism failure, it would most likely result in sediment delivery to nearby Hyalite Creek, but the sediment would probably not be delivered all at once resulting in any direct effects.

The construction of temporary roads within the Hyalite Creek watershed (5.8 miles) together with the treatment of 1,946 acres are projected to increase sediment delivery rate from 5.8% to 7.2% over natural. This equates to a maximum annual increase of 0.3% in the percent of fine sediment in spawning substrate (Table 5 and 9).

In the Bozeman Creek watershed, 2,955 acres would be treated and 1.3 miles of temporary roads would be constructed. This would increase the projected sediment delivery rate from 3.4% to 6.8% over natural. This equates to a maximum annual increase of 0.8% in the percent of fine sediment in spawning substrate. These figures also include the treatment of City of Bozeman lands.

The stream channel types along both Hyalite and Bozeman creeks have a moderate capacity to carry and flush sediment. Predicted increases in percent fines in spawning substrate are expected to be short-term. Changes in pool habitat quality (i.e., primarily filling of pools) are expected to be minimal and short-term, if any at all.

Under this alternative, 1.8 miles of temporary road would be built and 526 acres would be treated within the Leverich Creek watershed. This would result in a projected increase in the project sediment delivery rate from 8.4% to 34.9% over natural resulting in a maximum projected annual increase of 6.4% in the percent of fine sediment in spawning substrate.

These projected maximum increases in fine sediment would have the following biological effect on trout species that occupy these streams. Percent egg-to-fry survival for westslope cutthroat trout in Leverich Creek would be reduced by 16.3% down from 51.4% (Irving and Bjornn, 1984). This compares to a 2.0% reduction in egg-to-fry survival for rainbow trout in Bozeman Creek and 0.8% in Hyalite Creek down from 67.5%.

Westslope Cutthroat Trout Viability

See westslope cutthroat trout viability assessment under Alternative 1 for answers to questions 1, 2, and 4.

(3) How will recruitment and death rates be directly (e.g., habitat loss) and indirectly (e.g., increasing probability that stochastic events will affect the population) affected by management?

The implementation of Alternative 3 would reduce the probability of stand replacing and mixed severity fire at 10 to 20 years within the Leverich Creek drainage by 84% compared to Alternative 1 (Novak, 2007). After all treatments are completed, timber stands within the Leverich Creek drainages would have a weighted probability of stand replacing and mixed severity fire at 10 to 20 years of 5.4% as compared to 33.9% under Alternative 1. Because the Leverich Creek westslope cutthroat trout population is no longer connected to nearby populations, potential wildfire-related impacts associated with changes to water temperature regimes, bedload movement, stream channel stability, stream flow, sediment delivery, etc. could be major. There are too many naturally occurring variables to be able to adequately predict the kind and severity of these impacts.

The implementation of that portion of Alternative 3 within the Leverich Creek drainage would be expected to increase fine sediment in spawning habitat by 6.4%. This anticipated result would most likely have adverse effects to the quality of spawning habitat, quality of pool habitat, and macro-invertebrate populations and would further increase the risk of extinction of this small isolated population of westslope cutthroat trout. After all project generated sediments are flushed from the Leverich Creek watershed resulting from the proposed fuels reduction project, the sediment level in Leverich Creek would be reduced by 1.0% as a result of the implementation of reasonably foreseeable activities designed to reduce sediment (water and fish cumulative effect check list, project file).

Cumulative Effects of Alternative 3

The list of reasonably foreseeable actions would remain the same for all alternatives. The only difference in cumulative effects is those additive project related direct and indirect effects displayed by alternative. See Cumulative Effects check list.

Conclusions

The implementation of Alternative 3 would meet the Gallatin National Forest Travel Plan 30% standard for Percent Over Natural Sediment Delivery for the Hyalite Creek and Bozeman Creek analysis areas. Alternative 3 would have a small short-term effect on Management Indicator Species (wild trout) within the Hyalite Creek and Bozeman Creek analysis areas. Alternative 3 coupled with the recent road decommissioning within the Hyalite Creek analysis area would have beneficial effects on Management Indicator Species. Populations of Management Indicator Species are expected to remain viable within the entire Gallatin National Forest planning area (GNF 2010).

The implementation of Alternative 3 would not meet the Gallatin National Forest Travel Plan 30% standard for Percent Over Natural Sediment Delivery for the Leverich Creek analysis area. The probability of stand replacing fire and mixed severity fire within the Leverich Creek drainage would be reduced from 33.9% to 5.4%. It is expected that the portion of Alternative 3 within the Leverich Creek drainage would not meet the intent of the Implementation Strategy for 1999 Memorandum of Understanding and Conservation Agreement (MOUCA) for Westslope Cutthroat Trout in Montana as a result of increased sediment projections in the short term.

Table 5. Summary of fisheries indicators for Alternative 3.

Watershed	Meets Sediment Standard for Percent Over Natural Sediment Delivery for Class A Streams	Maximum Projected Change in Percent Fine Sediment	Minimum Projected Change in Percent Fine Sediment .
Bozeman	Yes	+0.8	0.0
Hyalite	Yes	+0.3	-0.5
Leverich *	No	+6.4	-1.0

This Alternative does not meet the intent of the MOUCA for Westslope Cutthroat Trout in Leverich drainage. Westslope cutthroat trout do not inhabit these analysis areas downstream of proposed treatment units in Bozeman and Hyalite Creeks.

The weighted probability of a stand replacing and mixed severity fire within Leverich Drainage in the next 10-20 years is 5.4%.

Alternative 3 is not consistent with all Applicable Laws, Regulations, Policy and Forest Direction as they pertain to westslope cutthroat trout in the Leverich Creek analysis area. Westslope cutthroat trout could always be restocked back into Leverich Creek once the habitat recovers from the proposed disturbance, but the local adaptation and associated genetic diversity that this local population brings to the upper Missouri River basin would be lost forever. If this were to occur, there would be an irreversible or irretrievable commitment of resources in the Leverich Creek watershed.

Direct and Indirect Effects of Alternative 4

No riparian timber harvest, landings, or temporary roads would occur under Alternative 4. Only thinning with hand pile burning or broadcast burning would occur. Riparian areas adjacent to perennial water bodies would be buffered to prevent fire from burning within the areas. Broadcast burning would be implemented in a manner to prevent head fires within riparian areas not associated with perennial water bodies. Broadcast burns within these riparian areas would be allowed to back down and creep around.

Treatment of 2,151 acres in the Hyalite Creek analysis area is projected to increase the sediment delivery rate above the existing level of 5.8% over natural. Coupled with the recent road decommissioning in the Hyalite Creek analysis area, there would be a projected reduction of 2.2% over natural to 3.6%. This equates to a projected decrease of 0.5% in the percent of fine sediment in spawning substrate in 2017 (Table 6 and 9).

In the Bozeman Creek analysis area, 2,337 acres would be treated. This would increase the projected sediment delivery rate from 3.4% to 5.3% over natural. This equates to a projected maximum annual increase of 0.5% in the percent of fine sediment in spawning substrate. These figures also include the treatment of City of Bozeman lands.

The stream channel types along both Hyalite and Bozeman creeks have a moderate capacity to carry and flush sediment. Predicted increases in percent fines in spawning substrate are expected to be short-term. Changes in pool habitat quality (i.e., primarily filling of pools) are expected to be minimal and short-term, if any at all.

Under this alternative, 355 acres would be treated within the Leverich Creek watershed. This would result in a projected increase in the sediment delivery rate from 8.4% to 9.7% over natural resulting in a maximum projected annual increase of 0.3% in the percent of fine sediment in spawning substrate.

Projected changes in percent fine sediment would have the following biological effect on trout species that occupy these streams. Percent egg-to-fry survival for westslope cutthroat trout in Leverich Creek would be reduced by 0.8% down from 51.4% (Irving and Bjornn, 1984). This compares to a 1.1% reduction (down from 67.5%) in egg-to-fry survival for rainbow trout in Bozeman Creek and 0.6% increase in egg-to-fry survival in Hyalite Creek.

Westslope Cutthroat Trout Viability

See westslope cutthroat trout viability assessment under Alternative 1 for answers to questions 1, 2, and 4.

(3) How will recruitment and death rates be directly (e.g., habitat loss) and indirectly (e.g., increasing probability that stochastic events will affect the population) affected by management?

The implementation of Alternative 4 would reduce the probability of stand replacing and mixed severity fire at 10 to 20 years within the Leverich Creek drainage by 70% compared to Alternative 1 (Novak, 2007). After all treatments are completed, timber stands within the Leverich Creek drainages would have a weighted probability of stand replacing and mixed severity fire at 10 to 20 years of 10.1% as compared to 33.9% under Alternative 1. Because the Leverich Creek westslope cutthroat trout population is no longer connected to nearby populations, potential wildfire-related impacts associated with changes to water temperature regimes, bedload movement, stream channel stability, stream flow, sediment delivery, etc. could be major. There are too many naturally occurring variables to be able to adequately predict the kind and severity of these impacts.

The implementation of that portion of Alternative 4 within the Leverich Creek drainage is expected to increase fine sediment in spawning habitat by 0.3%. This anticipated result would most likely have a small short-term adverse effect to the quality of spawning habitat, quality of pool habitat, and macroinvertebrate populations. After all project generated sediments are flushed from the Leverich Creek watershed resulting from the proposed fuels reduction project, the sediment level in Leverich Creek would be reduced by 1.0% as a result of the implementation of reasonably foreseeable projects design to reduce sediment.

Cumulative Effects of Alternative 4

The list of reasonably foreseeable actions would remain the same for all alternatives. The only difference in cumulative effects is those additive project related direct and indirect effects displayed by alternative. See Cumulative Effects check list.

Summary Conclusions

The implementation of Alternative 4 would meet the Gallatin National Forest Travel Plan 30% standard for Percent Over Natural Sediment Delivery for the Hyalite, Bozeman and Leverich Creek analysis areas. Alternative 4 would have a small short-term effect on Management Indicator Species (wild trout) within the Hyalite and Bozeman creek analysis areas. Populations of Management Indicator Species are expected to remain viable within the entire Gallatin National Forest planning area (GNF 2010).

Table 6. Summary of fisheries indicators for Alternative 4.

Watershed	Meets Sediment Standard for Percent Over Natural Sediment Delivery for Class A Streams	Maximum Projected Change in Percent Fine Sediment	Minimum Projected Change in Percent Fine Sediment .
Bozeman	Yes	+0.5	0.0
Hyalite	Yes	-0.3	-0.5
Leverich *	Yes	+0.3	-1.0

This Alternative does meet the intent of the MOUCA for Westslope Cutthroat Trout in Leverich drainage. Westslope cutthroat trout do not inhabit these analysis areas downstream of proposed treatment units in Hyalite and Bozeman Creeks.

The weighted probability of a stand replacing and mixed severity fire within Leverich Drainage in the next 10-20 years is 10.1%.

Alternative 4 would result in a projected maximum increase in percent fines in spawning substrate of 0.3% in Leverich Creek. When factoring in all sediment producing activities including reasonably foreseeable activities, there would be net reduction by 1.0% reduction in sediment levels in Leverich Creek. There would be a reduction in probability of fire with a projected minimal short-term increase in percent fines. The probability of stand replacing fire and mixed severity fire within the Leverich Creek drainage would be reduced from 33.9% to 10.1%. It is expected that the portion of Alternative 4 within the Leverich Creek drainage would meet the intent of the Implementation Strategy for 1999 Memorandum of Understanding and Conservation Agreement (MOUCA) for Westslope Cutthroat Trout in Montana. If implemented, Alternative 4 would be consistent with all Applicable Laws, Regulations, Policy and Forest Direction. There would be no irreversible or irretrievable commitment of resources.

Direct and Indirect Effects of Alternative 5

No riparian timber harvest, landings, and/or major stream crossings would occur under Alternative 5. Riparian areas adjacent to perennial water bodies would be buffered to prevent fire from burning within these areas. Broadcast burning would be implemented in a manner to prevent head fires within riparian areas not associated with perennial water bodies. Broadcast burns within these riparian areas would be allowed to back down and creep around. All proposed temporary roads are located away from major streams. Several of the proposed temporary roads would cross headwater drainages which may or may not be wet. No proposed temporary roads would be constructed through areas of high mass wasting hazard (Keck, 2010). As a result, no direct effects are expected to occur under Alternative 5.

The following design features were included in Alternative 5 specifically for the Leverich Creek drainage and were used to model projected changes in sediment delivery: 1) all skyline units and most ground based logging treatment units would be dropped as compared to Alternatives 2 and 3; 2) a 100-foot buffer along both forks of Leverich Creek would be left untreated to act as a sediment buffer and to provide long-term supply of large woody debris to the perennial and intermittent streams; 3) areas of concentrated drainages would be eliminated from treatment units; and, 4) a compacted slash filter windrow would be constructed during and immediately below temporary Road B-50 where deemed necessary to reduce sediment delivery to Leverich Creek.

The construction of temporary roads within the Hyalite Creek watershed (2.8 miles) together with the treatment of 1,686 acres are projected to increase the sediment delivery rate above the existing level of 5.8% over natural. Couple with the recent road decommissioning in the Hyalite Creek analysis area, there would be a projected reduction of 2.2% over natural to 3.6%. This equates to a projected decrease of 0.5% in the percent of fine sediment in spawning substrate in 2017 (Table 7 and 9).

The treatment of 3,051 acres within the Bozeman Creek watershed is projected to increase the sediment delivery rate from 3.4% to 6.0% over natural No temporary roads would be constructed within the Bozeman Creek analysis area on NFS lands. This equates to a projected maximum annual increase of 0.6% in the percent of fine sediment in spawning substrate. These figures also include the treatment of City of Bozeman lands.

The construction of temporary roads within the Leverich Creek watershed (0.3 miles) together with the treatment of 637 acres are projected to increase the sediment delivery rate from 8.4% to 12.0% over natural. This equates to a maximum annual increase of 0.9% in the percent of fine sediment in spawning substrate.

Projected changes in percent fine sediment would have the following biological effect on trout species that occupy these streams. Percent egg-to-fry survival for westslope cutthroat trout in Leverich Creek would be reduced by 2.3% down from 51.4% (Irving and Bjornn, 1984). This compares to a 1.5% reduction (down from 67.5%) in egg-to-fry survival for rainbow trout in Bozeman Creek and 0.1% increase in egg-to-fry survival in Hyalite Creek.

Westslope Cutthroat Trout Viability

See westslope cutthroat trout viability assessment under Alternative 1 for answers to questions 1, 2, and 4.

(3) How will recruitment and death rates be directly (e.g., habitat loss) and indirectly (e.g., increasing probability that stochastic events will affect the population) affected by management?

The implementation of Alternative 5 would reduce the probability of stand replacing and mixed severity fire at 10 to 20 years within the Leverich Creek drainage by 84% compared to Alternative 1 (Novak, 2007). After all treatments are completed, timber stands within the Leverich Creek drainages would have a weighted probability of stand replacing and mixed severity fire at 10 to 20 years of 5.5% as compared to 33.9% under Alternative 1. Because the Leverich Creek westslope cutthroat trout population is no longer connected to nearby populations, potential wildfire-related impacts associated with changes to water temperature regimes, bedload movement, stream channel stability, stream flow, sediment delivery, etc. could be major. There are too many naturally occurring variables to be able to adequately predict the kind and severity of these impacts.

The implementation of that portion of Alternative 5 within the Leverich Creek drainage is expected to increase fine sediment in spawning habitat by 0.9%. This anticipated result would most likely have a small short-term adverse effect to the quality of spawning habitat, quality of pool habitat, and macroinvertebrate populations. After all project generated sediment is flushed from the Leverich Creek watershed resulting from the proposed fuels reduction project, the sediment level in Leverich Creek would be reduced by 1.0% as a result of the implementation of reasonably foreseeable projects designed to reduce sediment.

Cumulative Effects of Alternative 5

The list of reasonably foreseeable actions would remain the same for all alternatives. The only difference in cumulative effects is those additive project related direct and indirect effects displayed by alternative. See Cumulative Effects check list.

Conclusions

The implementation of Alternative 5 would meet the Gallatin National Forest Travel Plan 30% standard for Percent Over Natural Sediment Delivery for the Hyalite Creek and Bozeman Creek analysis areas. Alternative 5 would have a small short-term effect on Management Indicator Species (wild trout) within the Hyalite and Bozeman creek watersheds. Alternative 5 coupled with the recent road decommissioning within the Hyalite Creek analysis area would have beneficial effects on Management Indicator Species. Populations of Management Indicator Species are expected to remain viable within the entire Gallatin National Forest planning area (GNF 2010).

The implementation of Alternative 5 would meet the Gallatin National Forest Travel Plan 30% standard for Percent Over Natural Sediment Delivery for the Leverich Creek analysis area. Although, Alternative 5 would result in a projected maximum increase in percent fines in spawning substrate of 0.9% in Leverich Creek in the short-term. It is expected that sediment levels would remain elevated for two years. Alternative 5 combines the benefits of wildfire reduction and minimizes short-term impacts from sediment delivery. The probability of stand replacing fire and mixed severity fire within the Leverich Creek drainage would be reduced from 33.9% to 5.5%. When factoring in all sediment producing activities including reasonably foreseeable activities, there would be net reduction by 1.0% in sediment levels in Leverich Creek starting in 2013. It is expected that the portion of Alternative 5 within the Leverich Creek analysis area meets the intent of the Implementation Strategy for 1999 Memorandum of Understanding and Conservation Agreement (MOUCA) for Westslope Cutthroat Trout in Montana.

Table 7. Summary of fisheries indicators for Alternative 5.

Watershed	Meets Sediment Standard for Percent Over Natural Sediment Delivery for Class A Streams	Maximum Projected Change in Percent Fine Sediment	Minimum Projected Change in Percent Fine Sediment .
Bozeman	Yes	+0.6	0.0
Hyalite	Yes	0.0	-0.5
Leverich *	Yes	+0.9	-1.0

This Alternative does meet the intent of the MOUCA for Westslope Cutthroat Trout in Leverich drainage. Westslope cutthroat trout do not inhabit these analysis areas downstream of proposed treatment units in Hyalite and Bozeman Creeks.

The weighted probability of a stand replacing and mixed severity fire within Leverich Drainage in the next 10-20 years is 5.5%.

If implemented, Alternative 5 would be consistent with all Applicable Laws, Regulations, Policy and Forest Direction. There would be no irreversible or irretrievable commitment of resource.

Direct and Indirect Effects of Alternative 6

No riparian timber harvest, landings, and/or major stream crossings would occur under Alternative 6. Riparian areas adjacent to perennial water bodies would be buffered to reduce the risk of fire from burning within these areas along Class 1 streams. Broadcast burning along Class 2 and 3 streams would be implemented in a manner to prevent head fires within riparian areas. Class 1, 2 and 3 streams are defined in Appendix A. Broadcast burns within these riparian areas would be allowed to back down and creep around. All proposed temporary roads are located away from major streams. Several of the proposed temporary roads would cross headwater drainages which may or may not be wet. No proposed temporary roads would be constructed through areas of high mass wasting hazard (Keck, 2010). As a result, no direct effects are expected to occur under Alternative 6.

The following design features were included in Alternatives 5 and 6 specifically for the Leverich Creek drainage and were used to model projected changes in sediment delivery: 1) all skyline units and most ground based logging treatment units would be dropped as compared to Alternatives 2 and 3; 2) a 100-foot buffer along both forks of Leverich Creek would be left untreated to act as a sediment buffer and to provide long-term supply of large woody debris to the perennial and intermittent streams; 3) areas of concentrated drainages would be eliminated from treatment units; and, 4) a compacted slash filter windrow would be constructed during and immediately below temporary Road B-50 where deemed necessary to reduce sediment delivery to Leverich Creek.

The construction of temporary roads within the Hyalite Creek watershed (2.2 miles) together with the treatment of 1,102 acres are projected to increase the sediment delivery rate above the existing level of 5.8% over natural. Coupled with the recent road decommissioning in the Hyalite Creek analysis area, there would be a projected reduction of 2.2% over natural to 3.6%. This equates to a projected decrease of 0.5% in the percent of fine sediment in spawning substrate in 2016 (Table 8 and 9).

The treatment of 2,524 acres within the Bozeman Creek watershed is projected to increase the sediment delivery rate from 3.4% to 4.7% over natural. One tenth mile of temporary road would be constructed within the Bozeman Creek analysis area on NFS lands. This equates to a projected maximum annual increase of 0.3% in the percent of fine sediment in spawning substrate. These figures also include the treatment of City of Bozeman lands.

The construction of temporary roads within the Leverich Creek watershed (0.3 miles) together with the treatment of 637 acres are projected to increase the sediment delivery rate above the existing level of 8.4% over natural. Coupled with the recent trail and road decommissioning in the analysis area, there would be a projected reduction of 2.7% over natural in 2011. This equates to a projected decrease of 0.6% in the percent of fine sediment in spawning substrate.

Projected changes in percent fine sediment would have the following biological effect on trout species that occupy these streams. Percent egg-to-fry survival for westslope cutthroat trout in Leverich Creek would increase by 1.7% up from 51.4% (Irving and Bjornn, 1984). This compares to a 0.7% reduction (down from 67.5%) in egg-to-fry survival for rainbow trout in Bozeman Creek and 0.5% increase in egg-to-fry survival in Hyalite Creek.

Westslope Cutthroat Trout Viability

See westslope cutthroat trout viability assessment under Alternative 1 for answers to questions 1, 2, and 4.

(3) How will recruitment and death rates be directly (e.g., habitat loss) and indirectly (e.g., increasing probability that stochastic events will affect the population) affected by management?

The implementation of Alternative 6 would reduce the probability of stand replacing and mixed severity fire at 10 to 20 years within the Leverich Creek drainage by 81% as compared to Alternative 1 (Novak, 2007). After all treatments are completed, timber stands within the Leverich Creek drainage would have a weighted probability of stand replacing and mixed severity fire at 10 to 20 years of 6.5% as compared to 33.9% under Alternative 1. Because the Leverich Creek westslope cutthroat trout population is no longer connected to nearby westslope cutthroat trout populations, potential wildfire-related impacts associated with changes to water temperature regimes, bedload movement, stream channel stability, stream flow, sediment delivery, etc. could be major. There are too many naturally occurring variables to be able to adequately predict the kind and severity of these impacts.

Fine sediment (< 6.35 mm) presently makes up 22.9 percent of substrate within suitable spawning habitat along Leverich Creek based on sediment core data collected below the forks near the Forest boundary. Based on Irving and Bjorrn (1984), egg-to-fry survival under the current sediment level would be 51.4%. Based on visual observations, the majority of the sediment is coming in from the left fork which is fishless. Although percent surface fines were not measured upstream along the right fork, suitable spawning habitat appears to have lower levels of fine sediment as compared to below the forks. Cumulatively, percent fine sediment has been projected to decrease by 2.7% which equates to a projected 1.7% improvement in egg-to-fry survival.

Cumulative Effects of Alternative 6

The list of reasonably foreseeable actions would remain the same for all alternatives. The only difference in cumulative effects is those additive project related direct and indirect effects displayed by alternative. See Cumulative Effects check list.

Summary Conclusions

The implementation of Alternative 6 would meet the Gallatin National Forest Travel Plan 30% standard for Percent Over Natural Sediment Delivery for the Hyalite Creek and Bozeman Creek analysis areas. Alternative 6 would have a small short-term effect on Management Indicator Species (wild trout) within the Hyalite Creek and Bozeman Creek analysis areas. Alternative 6 coupled with the recent road decommissioning within the Hyalite Creek analysis area would have beneficial effects on Management Indicator Species. Populations of Management Indicator Species are expected to remain viable within the entire Gallatin National Forest planning area (GNF 2010).

The implementation of Alternative 6 would meet the Gallatin National Forest Travel Plan 30% standard for Percent Over Natural Sediment Delivery for the Leverich Creek analysis area. When factoring in all sediment producing activities, including reasonably foreseeable activities, there would be net reduction of 1.0% in sediment levels in Leverich Creek below the forks. Like Alternative 5, Alternative 6 combines the benefits of wildfire reduction and minimizes short-term impacts from sediment delivery. The probability of stand replacing fire and mixed severity fire within the Leverich Creek drainage would be reduced from 33.9% to 6.5%. It is expected that the portion of Alternative 6 within the Leverich Creek analysis area would meet the intent of the Implementation Strategy for 1999 Memorandum of Understanding and Conservation Agreement (MOUCA) for Westslope Cutthroat Trout in Montana.

Table 8. Summary of fisheries indicators for Alternative 6.

Watershed	Meets Sediment Standard for Percent Over Natural Sediment Delivery for Class A Streams	Maximum Projected Change in Percent Fine Sediment	Minimum Projected Change in Percent Fine Sediment.
Bozeman	Yes	+0.3	0.0
Hyalite	Yes	-0.2	-0.5
Leverich *	Yes	-0.6	-1.0

This Alternative does meet the intent of the MOUCA for Westslope Cutthroat Trout in Leverich drainage. Westslope cutthroat trout do not inhabit these analysis areas downstream of proposed treatment units in Hyalite and Bozeman Creeks.

The weighted probability of a stand replacing and mixed severity fire within Leverich Drainage in the next 10-20 years is 6.5%.

Alternative 6 would be consistent with all Applicable Laws, Regulations, Policy and Forest Direction. There would be no irreversible or irretrievable commitment of resources.

Design Features incorporated in action alternatives for resource protection.

The following design features are primarily related to sediment. In the effects analysis, sediment delivery modeling takes into consideration the benefits of the following design features for Alternatives 5 and 6. These recommended design features have been incorporated into the alternatives (FEIS p. 2-16, Appendix B 12-14, SFEIS, Appendix A).

- A slash filter windrow would be installed below proposed temporary road B-50, within the Leverich drainage, as needed. This mitigation affects about ¼ mile of road and is limited to the areas where soil movement could be directed to any water. The Forest hydrologist would identify the areas of concern.
- There would be no skidding down to FS Road # 3166 or jump up roads constructed from FS Road # 3166 up to treatment unit 13C within that portion of treatment unit 13C within the Leverich Creek drainage.
- There would be no riparian treatment up to 100 feet either side of streams unless it is necessary to meet fuel treatment objectives. If required to meet fuel objectives, the following three riparian treatment strategies would be implemented to protect watershed and aquatic resource values: A) Stream Management Zone (SMZ) Guidelines: B) Modified SMZ Guidelines; and, C) No Cut or Treatment Buffers. The selected treatment strategy is dependent on location within the project area, proposed treatment type, and stream class (as defined below by the Streamside Management Zone Laws and Rules (DNRC 2006). These riparian treatment strategies are included in Appendix A to the SFEIS.

Table 9. The potential incremental change in the percentage of fine sediment in spawning substrate at three points of measurement for all alternatives. Estimated annual percentages over natural sediment delivery rates were used to derive these data and they are located in the Watershed Section (Story 2010).

Projected Annual Increase in Percent Fine Substrate by Alternative in Bozeman Creek At the Water Intake.

Year	1	2	3	4	5	6
2010	0.0	0.0	0.0	0.0	0.0	0.0
2011	0.0	+0.4	+0.6	+0.4	+0.4	+0.2
2012	0.0	+0.5	+0.8	+0.4	+0.5	+0.3
2013	0.0	+0.6	+0.8	+0.5	+0.6	+0.3
2014	0.0	+0.3	+0.5	+0.2	+0.4	+0.2
2015	0.0	+0.2	+0.3	+0.1	+0.2	+0.1
2016	0.0	0.0	0.0	0.0	0.0	0.0

Projected Annual Increase in Percent Fine Substrate by Alternative in Hyalite Creek At the Water Intake.

Year	1	2	3	4	5	6
2010	0.0	0.0	0.0	0.0	0.0	0.0
2011	-0.5	-0.3	0.0	-0.3	-0.3	-0.4
2012	-0.5	-0.2	+0.1	-0.3	-0.1	-0.4
2013	-0.5	-0.2	+0.3	-0.3	0.0	-0.3
2014	-0.5	-0.3	-0.1	-0.3	-0.2	-0.2
2015	-0.5	-0.4	-0.2	-0.5	-0.3	-0.4
2016	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5

Projected Annual Increase in Percent Fine Substrate by Alternative in Leverich Creek At the Forest Boundary.

Year	1	2	3	4	5	6
2008	0.0	0.0	0.0	0.0	0.0	0.0
2009	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0
2010	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0
2011	-1.0	+4.5	+4.7	+0.1	+0.6	-0.6
2012	-1.0	+6.0	+6.4	+0.2	+0.9	-0.8
2013	-1.0	+5.1	+6.4	+0.3	-0.1	-0.8
2014	-1.0	+3.8	+4.1	-0.7	-0.5	-0.9
2015	-1.0	+1.3	+1.4	-0.9	-0.9	-1.0
2016	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0

Table 10. Summary of four fisheries indicators for all alternatives.

Alternative	Watershed	Meet Sediment Standard for Percent Over Natural Sediment Delivery for Class A Streams?	Projected Change in Percent Fine Sediment		Meet the Intent of Westslope Cutthroat Trout MOUCA?	Weighted Probability of a Stand Replacing and Mixed Severity Fire Within Leverich Drainage (10 to 20 yr.)
			Maximum	Minimum		
1	Bozeman	Yes	0.0	0.0	-	
	Hyalite	Yes	0.0	-0.5	-	
	Leverich	Yes	0.0	-1.0	Yes	33.9%
2	Bozeman	Yes	+0.6	0.0	-	
	Hyalite	Yes	-0.2	-0.5	-	
	Leverich	No	+6.0	-1.0	No	15.0%
3	Bozeman	Yes	+0.8	0.0	-	

Alternative	Watershed	Meet Sediment Standard for Percent Over Natural Sediment Delivery for Class A Streams?	Projected Change in Percent Fine Sediment		Meet the Intent of Westslope Cutthroat Trout MOUCA?	Weighted Probability of a Stand Replacing and Mixed Severity Fire Within Leverich Drainage (10 to 20 yr.)
			Maximum	Minimum		
	Hyalite	Yes	+0.3	-0.5	-	
	Leverich	No	+6.4	-1.0	No	5.4%
4	Bozeman	Yes	+0.5	0.0	-	
	Hyalite	Yes	-0.3	-0.5	-	
	Leverich	Yes	+0.3	-1.0	Yes	10.1%
5	Bozeman	Yes	+0.6	0.0	-	
	Hyalite	Yes	0.0	-0.5	-	
	Leverich	Yes	+0.9	-1.0	Yes	5.5%
6	Bozeman	Yes	+0.3	0.0	-	
	Hyalite	Yes	-0.2	-0.5	-	
	Leverich	Yes	-0.6	-1.0	Yes	6.5%

- = westslope cutthroat trout do not inhabit these analysis areas downstream of proposed treatment units.

* = assuming the watershed remains intact without any high severity or high intensity fires.

The following Stewardship Opportunities if implemented would also improve sediment levels above and beyond what is already projected for Leverich Creek. Since the majority of the Leverich Canyon Road is considered a Public Road of which Gallatin County has full maintenance responsibilities, the following list of opportunities are only that, opportunities. The implementation of these opportunities depends on full cooperation with the County and funding. All of the sediment delivery modeling to date does not take into consideration the benefits of these opportunities.

Stewardship Opportunities

Place 6 inch minus gravel mixture along eroding segments of the Leverich Canyon Road from the lower culvert to the top of the steep pitch just above the upper culvert, and associated drainage ditches.

Improve effectiveness of cross drainage structures along the Leverich Canyon Road from the lower culvert to the top of the steep pitch just above the upper culvert.

Surface the entire Leverich Canyon Road from the lower culvert to the top of the steep pitch just above the upper culvert.

Consistency with Laws, Regulations, Policies, and Forest Direction

Presidential Executive Order 12962

Alternatives 1, 4, 5, and 6 would conserve aquatic systems to provide for increased recreational fishing opportunities nationwide for all the analysis areas. Because of projected increases in sediment delivery within the Leverich Creek drainages, Alternatives 2 and 3 would not meet the intent of this executive order.

Sensitive Species

Westslope cutthroat trout only inhabit a portion of the project area, that being the Leverich Creek drainage. Alternatives 1, 4, 5, and 6 would not jeopardize the viability of the population of westslope cutthroat trout within the Leverich Creek drainage. Although all action alternatives show the potential for a dramatic reduction in fire severity within the Leverich Creek analysis area, the implementation of Alternatives 2 and 3 could jeopardize the viability of this isolated population of westslope cutthroat trout as a result of increased sediment delivery.

Implementation Strategy for the 1999 Westslope Cutthroat Trout Conservation Agreement/MOU within the Upper Missouri River Basin

Westslope cutthroat trout only inhabit a portion of the project area, that being the Leverich Creek drainage. Alternatives 1, 4, 5, and 6 would provide the level of protection to ensure their long-term persistence and prevent unacceptable aquatic/riparian habitat degradation as required by this strategy.

Gallatin Forest Plan Direction

Forest-Wide

Fish and Wildlife A-14: The Forest will be managed to maintain and, where feasible, improve fish habitat capacity to achieve cooperative goals with Montana Fish, Wildlife and Parks and to comply with State water quality standards. See language above regarding the Implementation Strategy for the 1999 Westslope Cutthroat Trout Conservation Agreement/MOU within the Upper Missouri River Basin and Sensitive Species.

Management Area 7 (Riparian Areas)

Fish and Wildlife 2: Provide for optimum water temperatures for cold-water fish species. All alternatives would maintain optimum water temperatures for cold-water species because of design riparian buffers. Because of effective mitigation measures protecting riparian buffers, water temperature would be maintained and therefore is not an issue; therefore it was not analyzed.

Fish and Wildlife 3: Maintain minimum instream flows. All alternatives would maintain existing instream flow regimes. According to Story (2010), none of the alternatives would result in significant changes in the timing and water yield within any of the analysis areas.

Fish and Wildlife 4: Maintain suitable habitats for those species of birds, mammals, and fish that are totally or partially dependent upon riparian areas for their existence. See language above regarding the Implementation Strategy for the 1999 Westslope Cutthroat Trout Conservation Agreement/MOU within the Upper Missouri River Basin and Sensitive

Species. A Forest Plan amendment would be required to implement Alternatives 2 and 3 within the Leverich Creek drainage.

Gallatin Forest Travel Plan Direction (2006)

Standard E-4: Water, Fisheries, and Aquatic Life. In watersheds with streams currently at or above fish habitat management objectives, proposals for road and trail construction, reconstruction and maintenance will be designed to not exceed annual sediment delivery levels in excess of those in Table 2. Alternatives 1, 4, 5, and 6 would not exceed the 30% annual sediment delivery standard for Class A streams. A Travel Plan modification would be required to implement Alternatives 2 and 3 since they would exceed the 30% annual sediment delivery standard. Since the Implementation Strategy for the 1999 Westslope Cutthroat Trout Conservation Agreement/MOU within the Upper Missouri River Basin and Sensitive Species policy are more constraining than the Travel Plan, they would also have to be amended.

Standard E-5: Water, Fisheries, and Aquatic Life. Proposed roads and trails shall not be located in the floodplains or rivers and streams or in wetlands except where necessary to cross a stream or wetland with appropriate permits. Proposed temporary roads and skid trails under all action alternatives would meet this standard.

Standard E-6: Water, Fisheries, and Aquatic Life. Stream crossing facilities for proposed roads and trails shall allow for passage of aquatic organisms, by avoiding stream channel constriction or alteration of the flow pattern, except where passage restriction is desired to isolate genetically pure cutthroat trout populations from exposure to hybridization or competition by non-native salmonids. None of the proposed temporary roads or associated stream crossings under any of the action alternatives would cross fish bearing streams. All stream crossing facilities would be removed upon project completion.

Standard E-7: Water, Fisheries, and Aquatic Life. Road materials should not be side-cast into streams or wetlands. Maintenance and construction activities along existing roads and proposed temporary roads and skid trails under all action alternatives would meet this standard.

Biological Evaluation

The following Biological Evaluation is for the preferred alternative only.

Westslope Cutthroat Trout

Based on genetic data (both current and past), the only streams within the project area occupied by westslope cutthroat trout are Leverich Creek and Wildhorse Creek. A comment was made on the DEIS that old data were being used to determine the presence or absence of westslope cutthroat trout within the project area. There is no published or grey literature science available that states that extinct westslope cutthroat trout populations resulting from either genetic introgression or nonnative invasion would recolonize on their own. Recovery from these events requires the intervention of management agencies. The use of old data is extremely valuable when determining when westslope cutthroat trout of 90% or greater genetic variability currently exist.

Although Wildhorse Creek is located within the project area, it is located far upstream from any proposed treatment units. Westslope cutthroat trout within Wildhorse Creek are presently isolated from any downstream fisheries by natural barriers. Alternative 6 would have "No Impact" on this population.

Alternative 6 would raise sediment delivery 1.3% over natural above the existing 4.4%. This equates to a projected 0.4% reduction in egg-to-fry survival. Taking into account all the road and trail decommissioning that have already occurred within the drainage, sediment delivery rates and sediment levels (percent fines < 6.35 mm) would be less during and immediately after the implementation of Alternative 6 as compared to when this population was first discovered in 2006. When factoring in all these completed activities, there would be a net reduction by 1.0% in sediment levels in Leverich Creek in 2015. Additional benefits would be realized when the Leverich Canyon Road is improved reducing sediment delivery, the proposed fish migration barrier is constructed, and nonnative eastern brook trout are removed. Overall, the Leverich Creek population of westslope cutthroat trout would be in much better shape in 2015 as compared to 2006 when it was first discovered. Following implementation of Alternative 6, the probability of a stand replacing and mixed severity fire within the Leverich Creek drainage (10 to 20 years later), would be 6.5% as compared to 33.9% (81% reduction) before implementation. This would be an important factor in maintaining the viability of this isolated population.

For these reasons, I have determined that the implementation of Alternative 6 within the Leverich Creek analysis area would have "No Impact" on this population of westslope cutthroat trout. (Prepared by Bruce Roberts, Fisheries Biologist)

Fluvial Arctic Grayling

Native fluvial Arctic grayling are not known to occur within the project area or immediately downstream. The Arctic grayling that do inhabit the project area (i.e., Hyalite Reservoir and Emerald and Heather lakes) have been stocked and are not native to the project area. For this reason, I have determined that the implementation of Alternative 6 would have "No Impact" on fluvial Arctic grayling.

Western Pearlshell Mussel

Western pearlshell mussels are native to western Montana (upper Missouri River, Clark Fork, and Flathead River drainages). As do most mussels, this species requires an intermediate fish host to be present (Montana's State Official Website 2010) to fulfill their life cycle. The nearest known population of western pearlshell mussel is located just to the north of the Bozeman Municipal Watershed project area along the East Fork of the Gallatin River. If present in the project area, they would most likely inhabit low gradient fish bearing streams with wetted widths greater than 2.0 meters. This would include such streams as Bozeman Creek up to the barrier falls described in the Affected Environment section and Hyalite Creek up to Middle Creek Dam (Hyalite Dam) and above. Even though no direct surveys have been conducted within the project area, no shells from dead individuals have been observed along any of the project area streams while conducting other fisheries or aquatic habitat surveys.

Alternative 6 would not jeopardize the continued existence of this species, if determined present. Project design features and mitigation measures previously listed were developed to minimize or eliminate impacts to aquatic organism and their habitat. To jeopardize the existence of mussel beds, it would take such major events as landslides that could potentially bury the beds or negatively affect individual's ability to filter food or combination of events that could destabilize the stream channels enough to cause bedload movement crushing these immobile organisms. It is believed that Alternative 6 would not result in any such events. As a result, Alternative 6 would have “No Impact” on the western pearlshell mussel.

Issues: Other Sensitive Species

Changes between the Final and Supplemental EIS

In Issue #21- Other Sensitive Species Not Affected, the FEIS mistakenly reported that sensitive plant surveys had not been conducted in the project area. Sensitive plant surveys were completed for proposed treatment units in 2008 (surveys documented in project record). This information replaces the Sensitive Plant discussion in the FEIS on p. 3-418 to 419.

Introduction

Sensitive species are those plant and animal species identified by the Regional Forester for which population viability is of concern. All Forest Service planned, funded, executed or permitted programs and activities are to be reviewed for possible effects on sensitive species (FSM 2672.4) Several species are identified as sensitive on the Regional Forester's Sensitive Species list (USDA FS R1 2004), but are not known or suspected to occur within the project area due to habitat limitations. Mitigation language will be updated in the record of decision.

Sensitive Plant Species

Most sensitive plant species on the Gallatin National Forest are associated with relatively undisturbed, and often fragile, environments such as alpine areas, wet sites and riparian habitat. Proposed treatment areas (burns and thinning units) are generally on dry, open slopes or in lower elevation, roaded and developed areas. None of the treatment units are in wet, riparian or alpine habitat where sensitive plant species are expected to occur. Sensitive plant surveys were completed for proposed treatment units in 2008 (surveys documented in project record). No sensitive plant species were found in any of the surveyed areas. Extensive field work was completed in 2010 for various resources and again no sensitive plant species were discovered. Should any sensitive plant populations subsequently (i.e. during project layout or implementation) be identified in proposed treatment units, standard contract provisions allow for modification to protect previously undiscovered species from harm that could result from proposed treatment. Such mitigation could include timing restrictions, area restrictions, changes in treatment methods, or any combination thereof. Since surveys of the affected areas revealed no existing sensitive plants in proposed treatment units, and effective mitigation could be used to protect sensitive plant populations should any be found before or during project implementation, the proposed action would have no impact on sensitive plants.

Issue: Soils

Changes between Final and Supplemental EIS

This analysis replaces in its entirety the soils analysis in the FEIS (p. 3-317 to 3-346). In response to the remand of the project decision based on soils analysis and disclosure, a decision was made to start affresh with data collection and a field based analysis. As a result, the analyses and conclusions disclosed in this analysis are based on extensive field sampling and soil monitoring in the project area and proposed treatment units during the summer and fall of 2010. These data show that the level of detrimental soil disturbance (DSD) from past harvesting is well below the original estimate in the FEIS and below the allowable 15 percent DSD limit for Region One Forests. Surface soil textures for the majority of proposed partial harvest and/or mechanical thinning units are primarily loamy sand or sandy loams. Soil compaction which is a major source of detrimental soil disturbance in finer textured soils was not found to be a serious problem in the coarse textured soils of the Bozeman Municipal Watershed. Predicted levels of total DSD at the end of the project would be below the 15% Region One maximum standard for all treatment units in all fuel reduction alternatives.

Introduction and Statement of Issue

Issue

Proposed fuel treatments in the Bozeman Municipal Watershed Fuels project could potentially cause long term impairment of land productivity and reduced soil quality within treatment units if inadequately planned or implemented. Of specific interest is the level of detrimental soil disturbance created in tractor harvest and mechanical thinning areas, as well as the potential for increasing unauthorized, off road vehicle use in portions of the area.

Indicator

Measurement of detrimental soil disturbance, including the detrimental effects of compaction, displacement, rutting, severe burning, surface erosion, loss of soil organic matter, and soil mass movement, has been used in Region 1 as a surrogate measure to ensure that land productivity and soil quality are not impaired. Detrimental conditions are explained in this report and defined in the Keck 2010 and USFS-R1 1999. The Region wide standard requires that new activities be designed so they “do not create detrimental soil conditions on more than 15 percent of an activity area” (USFS-R1 1999). When detrimental soil disturbance (DSD) exists from prior management activities within treatments units, the combined DSD from past and currently planned management actions must not exceed 15% or must be less than prior DSD levels after mitigation measures are completed (USFS-R1 1999).

Concern

Reductions in soil productivity and soil quality could disrupt biological and hydrological functions of the soil in a manner that reduces the ability of National Forest lands to supply goods and services to the American public. Severe or extensive soil disturbance could potentially result in a downward spiral of land degradation.

Summary

There is previous commercial timber harvesting within and adjacent to many of the proposed treatment units of the Bozeman Municipal Watershed Fuels Project. Most of this past activity has been in areas that are proposed for possible mechanical thinning in small diameter stands. Other treatment units without past timber harvests have little or no prior activity related disturbance. Treatment units with a past timber harvests, especially clearcuts and patch clearcuts, show signs of past disturbance. An initial estimate of detrimental soil disturbance made by the former Soil Scientist of the Gallatin National Forest indicated that any treatment units “with evidence of past timber harvest” would have 22% detrimental soil disturbance (Shovic 2007a), regardless of past harvest extent or soil type. This estimate was made without soil monitoring in the BMW area and was based on the “forest-wide average” for the Gallatin National Forest (USFS-GNF 2010; Shovic 2007a).

Extensive soil sampling along with detailed soil monitoring for detrimental soil disturbance (DSD) was completed in the summer and fall of 2010 for treatment units of concern (having past harvest). These data show that the level of detrimental soil disturbance from past harvesting is well below the estimate in the FEIS (FEIS p. 3-322) and below the allowable 15 percent DSD limit for Region One Forests. Surface soil textures for the majority of proposed partial harvest and/or mechanical thinning units are primarily loamy sands or sandy loams. Soil compaction, a major source of detrimental soil disturbance in finer textured soils, was not found to be a serious problem in the coarse textured soils of the Bozeman Municipal Watershed.

Soil parent materials throughout most of the Bozeman Municipal Watershed were consistently coarse-grained gneiss, aplite, or granite. Each of these rock types results in coarse textured soils containing abundant rock fragments. Soils formed from granite tend to be somewhat more coarse-textured than the other two rock types. Changes in soils within this area relate more to topographic differences in slope, aspect, and elevation than to rock type. Steep, north-facing slopes often have seep areas and alder thickets interspersed with conifer stands. Gently sloping to moderately steep, bedrock-floored uplands in the middle of the Bozeman Municipal Watershed area are more droughty and tend to have shallow bedrock ledges. Soils of steeper south tending slopes are warmer and drier than other aspects and often have abundant rock fragments throughout the soil profile.

Soils are not a critical issue among the proposed treatments. The combination of mainly coarse textures and abundant rock fragments in subsoil layers helps limit their susceptibility to detrimental soil disturbance provided standard water erosion control best management practices incorporated in the alternatives are implemented along roads and trails.

Proposed fuels treatments in this project present a reasonable approach to reducing fuel loads. No treatments units are predicted to exceed the 15% maximum DSD standard for Region One at the end of the project for any of the proposed treatments. The primary soils-related concerns are that standard water erosion control measures be implemented on temporary roads or strongly sloping skid trails and that forest thinning in high use areas should be done in a manner which does not unintentionally increase the level of unauthorized, off-road motor vehicle use. These watershed protections were incorporated in the alternatives in the FEIS (p. 2-20) and SFEIS, Appendix A. Forest thinning prescriptions are designed to deter easy vehicle access. All action alternatives comply with standards in the Forest Plan for the Gallatin National Forest and meet the Region One detrimental soil disturbance standard. The no action alternative (Alternative 1) may pose the greatest threat to long term soil productivity if severe wildfires burn through forest stands currently containing excessive amounts of large woody fuels.

Background

Affected Environment

Soils in the Bozeman Municipal Watershed Fuels Treatment area are described in general by the Soil Survey of Gallatin National Forest, Montana (USFS et. al. 1996). Table 11 provides information about the relative abundance and distribution of soil survey map units within treatment units for the preferred Alternative (Alt. 6). Since all alternatives cover the same area, these same data relate to other alternatives as well. Relative abundance is indicated in the table by the following notation: **M** = map unit(s) that cover all or a major portion of the treatment unit, m = map units that are found in only a minor portion of treatment unit (≤25%), and tr = map units that occur only as a trace at the edge of a treatment unit. A total of nineteen soil map units were mapped in the soil survey within the treatment boundaries of the Bozeman Municipal Watershed Fuels Project. Of these, six (12-1C, 53-1D, 53-3C, 54-1A, 54-1B, and 54-1G) cover the majority of areas slated for mechanical thinning or partial harvest. They represent the dominant soil types in nearly all treatments units. An additional 7 soil map units are identified as being of limited extent. These soil map units occur in just a few treatment units but cover a large portion of at least one of them. Finally, there are 6 soils map units that occur only as minor or trace components at the margins of the project area, and are therefore not included in Tables 11, 12 and 13.

Table 11. Distribution of commonly occurring soil survey map units within Bozeman Municipal Watershed Treatment Units.

BMW Treatment Unit	Soil Map Units												
	12-1C	53-1A	53-1D	53-3C	54-1A	54-1B	54-1C	54-1G	54-2D	64-2C	86-2D	87-1D	87-2D
1A			M		m					m			
1B										M			
3			m		M			M		tr			
7A					M								
7B		m	tr		M								
7C		M	m		m		m						
8					M		m						
10			M		m		M						
11A					M			M					
11B					M	m							
13A					M		m						

BMW Treatment Unit	**Soil Map Units**												
	12-1C	**53-1A**	**53-1D**	**53-3C**	**54-1A**	**54-1B**	**54-1C**	**54-1G**	**54-2D**	**64-2C**	**86-2D**	**87-1D**	**87-2D**
13C					M		M	m					
14					tr		M						
16A								m	tr		M		M
16C											m		M
17								m	M				
19				tr								M	
20			M					m				m	
21B				M		m							
21C			M					m					
22C						M							
22K						M							
22L						M							
22l	tr					M							
22N	m					M							
22O						M							
22P	m					M							
22Q			M			M							
25	M							M					
25A					m			M					
26	M				tr								
27A					m			M					
28B	m				M								
28C					M			m					
33	M												
36B					m	M		M					
36C					m			M					
36D	m				m			M					
37							m	M					
38					m		M	M					

BMW Treatment Unit	Soil Map Units												
	12-1C	53-1A	53-1D	53-3C	54-1A	54-1B	54-1C	54-1G	54-2D	64-2C	86-2D	87-1D	87-2D
39											M		M
40			tr		M			m		tr			
45A								M					
45B								M					
45C			M					M					
999	M		M	M	m	m		m					

Treatment Units 32 and 33 have been combined to a single 999 unit in the Soils analysis for Alternative 6. Units 32 and 33 are both within the core area of BMW that was heavily havested 30 to 60 years ago. Planned treatments for both units are the same pre-commercial thinning in small diameter stands with some potential commercial havesting. This made combining the two units for analysis a reasonable approach. The analysis for Unit 999 in Alternative 6 was then based on subunits to allow for a more precise analysis that corresponds with past harvest locations and cutting boundaries. The differences are reflected in differences in the expected level of prior and post treatment, detrimental soil disturbance. Table 12 breaks out the distribution of soil mapping units within the individual subunits of Unit 999. Subunits are identified sequentially, starting with 99a and going through the alphabet to 99pp.

Table 12. Distribution of commonly occurring soil survey map units within subunits of Treatment Unit 999 in the Bozeman Municipal Watershed. Refer to past harvest maps (Figures 6, 7, and 8) for location of individual subunits.

BMW Treatment Unit	Soil Map Units												
	12-1C	53-1A	53-1D	53-3C	54-1A	54-1B	54-1C	54-1G	54-2D	64-2C	86-2D	87-1D	87-2D
99a	M					M							
99b	M					m							
99c	M												
99d	M							m					
99e	M				M								
99f	M		tr		tr								
99g						M							

BMW Treatment Unit	Soil Map Units												
	12-1C	53-1A	53-1D	53-3C	54-1A	54-1B	54-1C	54-1G	54-2D	64-2C	86-2D	87-1D	87-2D
99h	M												
99i	M												
99j	M												
99k	M					M							
99l	M		m			tr							
99m			M										
99n	tr		M										
99o	tr		M										
99p	M		M										
99q	M		m										
99r	M				m			m					
99s	m		M										
99t	m		M										
99u	M		M										
99v	M												
99w	M												
99x			M	m									
99y				M									
99z			tr	M		m							
99aa			tr	M									
99bb				M									
99cc			M	m		m							
99dd				M									

BMW Treatment Unit	Soil Map Units												
	12-1C	53-1A	53-1D	53-3C	54-1A	54-1B	54-1C	54-1G	54-2D	64-2C	86-2D	87-1D	87-2D
99ee				M									
99ff			M	M									
99gg			M	tr									
99hh			M										
99ii			M										
99jj			M	m									
99kk			M	m									
99ll			m	M									
99mm			m	tr				M					
99nn			M										
99oo			M					M					
99pp			M					m					

Assessment of Soil Landscape Information

The Soil Survey of the Gallatin National Forest fits the definition of an order 4, land type, soil survey. As such, it was never designed to provide sufficient detail or accuracy for management decisions at a project scale. It does, however, provide a good starting point for understanding the general distribution of soils in the area. Tables 13 and 14 show the primary landscape and soil attributes most relevant to the assessment of soil conditions occurring within the Bozeman Municipal Watershed area based on information in the Soil Survey. All data presented come from interpretive tables (#1, #5, and #13) in the Soil Survey of the Gallatin National Forest (USDA 1996) or were extracted from map unit descriptions in the Soil Survey.

Data in the Soil Survey has been supplemented by field reconnaissance, soil disturbance monitoring, and soil sampling within treatment units of the Bozeman Municipal Watershed by Tom Keck, current Soil Scientist for the Gallatin National Forest. Initial field reconnaissance of the entire area was followed by extensive field sampling and soil monitoring in selected treatment units. All soil monitoring analysis included examination of shallow soil pits (12 inch deep) to verify soil surface horizon conditions at each sample point along transects. Additional references consulted include Geologic Maps of the Bozeman 30' by 60' Quadrangle (Vuke, et.al, 2002) and the Livingston 30' by 60' Quadrangle (Berg, et.al. 2000), National Agricultural Imagery (NAIP) from 2009, and topographic maps of the area.

The discussion of soil resources that follows is based on information from the Soil Survey as well as field observations, soil sampling results, and information from these other sources.

Landscape Attributes

Landscape data from the Soil Survey of the Gallatin National Forest for the Bozeman Municipal Watershed area are presented in Table 13. Soil map units identified in the Soil Survey as occurring in this area do a reasonable job of identifying the major landforms and parent materials present. Field observations verify that the area as a whole is characterized by bedrock controlled mountain slopes. This assessment agrees with the Soil Survey except for unit 12-1C which was mapped in the less steeply sloping, "plateau region" of the project area and unit 53-3C discussed in the next few paragraphs.

Map unit 12-1C is identified in the Soil Survey as occurring on glaciated mountain ridges. Field observations do not substantiate glaciation in this area. Consultation with Dr. Cliff Montagne, Associate Professor at Montana State University and an expert on local geology, confirmed that evidence of past glaciation in Hyalite Canyon ends further up the canyon. The gently sloping to moderately steep portions of BMW are most accurately described as bedrock floored uplands or broad mountain ridges; not glaciated.

Table 13. Selected landscape attributes for soil map units in the Soil Survey of the Gallatin National Forest, Montana (1996) identified as occurring within the Bozeman Municipal Watershed Project area.

Map Unit	Landform	Slopes	Parent Material	Rock Outcrop%
Primary Soil Map Units in Project Area				
12-1C	Glaciated mtn. ridges[1]	6-20%	Granitic Rocks	NA
53-1D	Mountain slopes	10-45%	Granitic rocks	NA
53-3C	Mountain slopes	10-45%	Volcanic rocks[2]	NA
54-1A	Mountain slopes	45-70%	Granitic rocks	20%
54-1B	Mountain slopes	45-70%	Granitic rocks	40%
54-1G	Mountain slopes	45-70%	Granitic rocks	15%
Soil Map Units of Limited Extent				
53-1A	Mountains slopes	10-45%	Granitic rocks	15%
54-1C	Mountains slopes	45-70%	Granitic rocks	15%
54-2D	Mountains slopes	45-70%	Sandstone & shale	15%
64-2C	Flood plains and terraces	0-10%	Glacial outwash & alluvial deposits	0

[1] This information varies significantly from field observations. See the explanation.
[2] Same as footnote 1.

Map Unit	Landform	Slopes	Parent Material	Rock Outcrop%
86-2D	Structurally controlled	10-45%	Sandstone & shale	NA
87-1D	Structurally controlled	45-70%	Limestone	20%
87-2D	Structurally controlled	45-70%	Sandstone & shale	NA

The Soil Survey of the Gallatin National Forest describes geology in rather broad terms. For BMW, "granitic" parent material refers to a mixture of coarse grained parent materials that are primarily gneiss, diorite, and granite, in that order of abundance. Prominent features and ridge tops are mainly gneiss. The geologic maps, referred to previously, indicate quartzofeldspathic gneiss as occurring throughout the core BMW area with bands of amphibolite and hornblende gneiss. Coarse grained rocks represented by all of these parent materials result in predominantly sandy to sandy loam soil textures with abundant rock fragments.

The Soil Survey indicates a large portion of the southeast part of BMW as being underlain by "volcanic rocks" in map unit 53-3C. Field observations do not confirm the presence of volcanic bedrock in this area. The southeast portion of BMW was one of the first areas examined. Only limited amount of volcanic rocks were found. USGS maps (Berg et. al 2000, Vuke, et. al 2002) show an area of Absaroka Volcanics to the south with the geologic contact running along the southern edge of the BMW treatment units. Information in the USGS maps agrees with field observations indicating limited influence of volcanic parent materials within the BMW treatment units.

Vegetation patterns on the 2009 NAIP imagery change just south of the BMW project area to more of a mosaic of interspersed grassland meadows and forested areas. This pattern is characteristic of volcanic parent materials which tend to support more areas of grassland vegetation than do coarse grained "granitic" parent materials (Keck personal observation).

Soil Properties

Lithology plays a major role in determining the soil texture, rock fragment content, and to a lesser extent, soil pH of young, bedrock controlled landscapes such as those found throughout much of the Rocky Mountains. All of the rock types occurring within the main portions of BMW, (gneiss, aplite and granite) tend to result in coarse textured soils. The primary soil textures noted along traverses and monitoring transects for surface mineral soil layers were sandy loams and loamy sands for all BMW areas sampled. Clay content for the majority of near-surface, mineral soil horizons sampled was approximately 6 to 14 percent clay. The Soil Survey of the Gallatin National Forest was inaccurate in this portion of the project area. Selected soil properties from the Soil Survey and field observations are presented in Table 14.

The Soil Survey identifies surface mineral soil layers in "granitic" areas as having high rock fragment contents. Surface mineral layer textures reported in representative profiles for the primary "granitic" map units in this area all have gravelly loam to very cobbly sandy loam textures (Table 14). Field sampling for this project was focused mainly on less steep (<35% slope) portions of BMW slated for tractor based harvesting. For those areas, abundant rock fragments were most often not found in upper mineral soil layers. Rock fragment contents in soil surface layers tended to be higher on steeper slopes. Thus, surface rock fragment contents reported in the Soil Survey for "granitic" rock types may accurately represent field conditions on steeper portions of BMW but not accurate in the less steep areas.

The presence of loam soil textures in the fine-earth fraction of surface layers, also reported in the Soil Survey (Table 14), is less likely to be accurate. Surface textures during field sampling were found to consistently be sandy loams or loamy sands. Near-surface, mineral soil textures on steeper slopes would have the tendency to be more coarse, given the parent materials present.

Field sampling results suggest that the Soil Survey generally overestimates clay contents in soils formed from coarse grained, "granitic" parent materials. Personal experience has shown that this is often the case with soil mapping in granite areas unless good use was made of available lab data. It is appears likely that future lab analysis of soils in this and other "granitic" areas of the Forest will result in the re-classification of family level particle-size classifications from loamy-skeletal to sandy-skeletal for areas with predominantly coarse grained parent materials. Subsoil textures in the particle-size control section, in that case, would likely be primarily loamy sands rather than sandy loams.

While only a limited amount of rock fragments were found in most of the surface, mineral soil horizons, rock fragment contents increased substantially with depth. Thus, the "skeletal" portion of the family classification for these soils appears reasonable given the type of parent materials present. 'Skeletal" at the family level of soil classification indicates more than 35% rock fragments are present in the particle-size control section (that portion of the soil used at the Family level of soil classification to determine particle-size class).

Table 14. Selected soil properties by soil map units in the Soil Survey of the Gallatin National Forest, Montana (1996) identified as occurring within the Bozeman Municipal Watershed Project area.

Map Unit	Surface Texture(s)	Particle-size Class	Fine-earth Fraction†	Soil Depth
Primary Soil Map Units in Project Area[3]				
12-1C	gr Loam/vcb SL	loamy-skeletal	sandy loam	(deep)
53-1D	gr Loam/vcb SL	loamy-skeletal	sandy loam	(deep)
53-3C	(Loam)	(fine-loamy)	(clay loam)	(deep)
54-1A	vgr Loam; gr SL	loamy-skeletal	sandy loam	shallow to deep
54-1B	gr Loam/vcb SL; SL	loamy-skeletal	sandy loam	(deep)
54-1G	gr Loam/vcb SL	loamy-skeletal	sandy loam	(deep)

[3] Information in () vaires from field observation –see the text . In addition, surface textures and particle size class data in coarse grained parent material appears to be skewed toward heavier soil textures than found in field sampling.

Map Unit	Surface Texture(s)	Particle-size Class	Fine-earth Fraction†	Soil Depth
Map Units of Limited Extent				
53-1A	Sandy Loam; Loam	loamy-skeletal	sandy loam	deep
54-1C	gr Loam/vcb SL	loamy-skeletal	sandy loam	deep
54-2D	SiL; CL; gr CL	loamy-skeletal	silt loam - clay loam	deep
64-2C	gr Loam; Loam	loamy-skeletal	loam	very deep
86-2D	Loam; vgr Loam	fine-loamy; fine	loam	deep
87-1D	gr Loam/vcb L; gr Loam	loamy-skeletal	sandy loam - loam	shallow to deep
87-2D	vgr Loam; gr Loam	loamy-skeletal	loam	deep

† Refers to the predominant texture of the less than 2mm fraction in the particle-size control section.

The area of volcanic parent materials is of special interest because the Soil Survey identifies loam surface textures, fine-loamy soils, and clay loam subsoil textures as associated with the volcanic parent materials. These soils would react quite differently to trafficking and disturbance by mechanical equipment during harvesting activities than the coarse textured soils identified as occurring throughout most of the BMW area. The soil textures noted above for volcanic soils were not found in the two subunits (99x and 99z) sampled within the expected area of volcanic parent materials with one exception in an open, grassland meadow near the southern edge of Unit 99z.

Soil map units 86-2D, 87-1D, and 87-2D in Tables 13 and 14 all relate to areas of sedimentary beds on the west side of BMW; west of Hyalite Creek. These map units as well as sedimentary parent materials in general are of limited extent within the main portion of BMW area.

Surface textures in the less sloping portions of BMW most often had few rock fragments in near-surface, mineral soil layers. Soil color of these near-surface layers also exhibited a distinct orange color in many instances. Generally orange colors like that in surface soil layers are associated with surface, volcanic ash layers in soils of western Montana and northern Idaho. Although soils in the BMW area do not have the same distinctive ash caps found elsewhere in the Northern Rockies, there have been past inputs of volcanic ash and other eolian materials added to surface soil layers in otherwise local bedrock derived (residuum) soils. Retaining this relatively rock-free surface mantle, when it is present, would be an important part of protecting soil resources within the BMW.

Overall, relatively coarse soil textures in upper mineral soil and subsoil layers along with abundant rock fragments in subsoil layers limits susceptibility of these soils to detrimental soil compaction or rutting. Precipitation tends to infiltrate into the soil rather than run off unless soils are frozen or they are sitting on top of shallow bedrock areas. Water that infiltrates into the soil rather than running off is good from a water erosion standpoint. That is why most USDA National Cooperative Soil Survey soil erodibility technical guides rate loam and silt loam textures as being most susceptible to water erosion and "sandy" soils as having a low potential for water erosion.

Sloping areas with shallow, relatively impervious bedrock change the above relationship, however. For coarse textured, shallow soils, water infiltrates into the soil until the layer immediately above the impervious bedrock contact becomes saturated. At that point, water begins to flow down slope along the top of the bedrock layer. Upslope contributing area increases down slope to a point where the area is large enough or depth to bedrock shallow enough that flowing water reaches the soil surface and becomes channelized flow. The net result can be soil erosion.

The Soil Survey severely underestimates the proportion of shallow soils in the BMW area, especially on gently sloping to moderately steep, mountain ridge top areas. The presence of relatively impervious bedrock at shallow depths increaases the potential for water erosion along unprotected roads and trails and helps explain why dirt roads in the BMW area become quickly gullied once road steepness exceeds threshold levels. Shallow bedrock or other impervious layers in the soil also explain why dirt two-track roads on level or slightly concave areas routinely become flooded by large puddles after rainstorms, despite coarse textured soils. Water is most likely ponding on top of impervious, shallow bedrock layers. Future soil profile sampling in this area, as part of the project-scale, soil survey update, will focus attention on the influence of shallow soils to resource management.

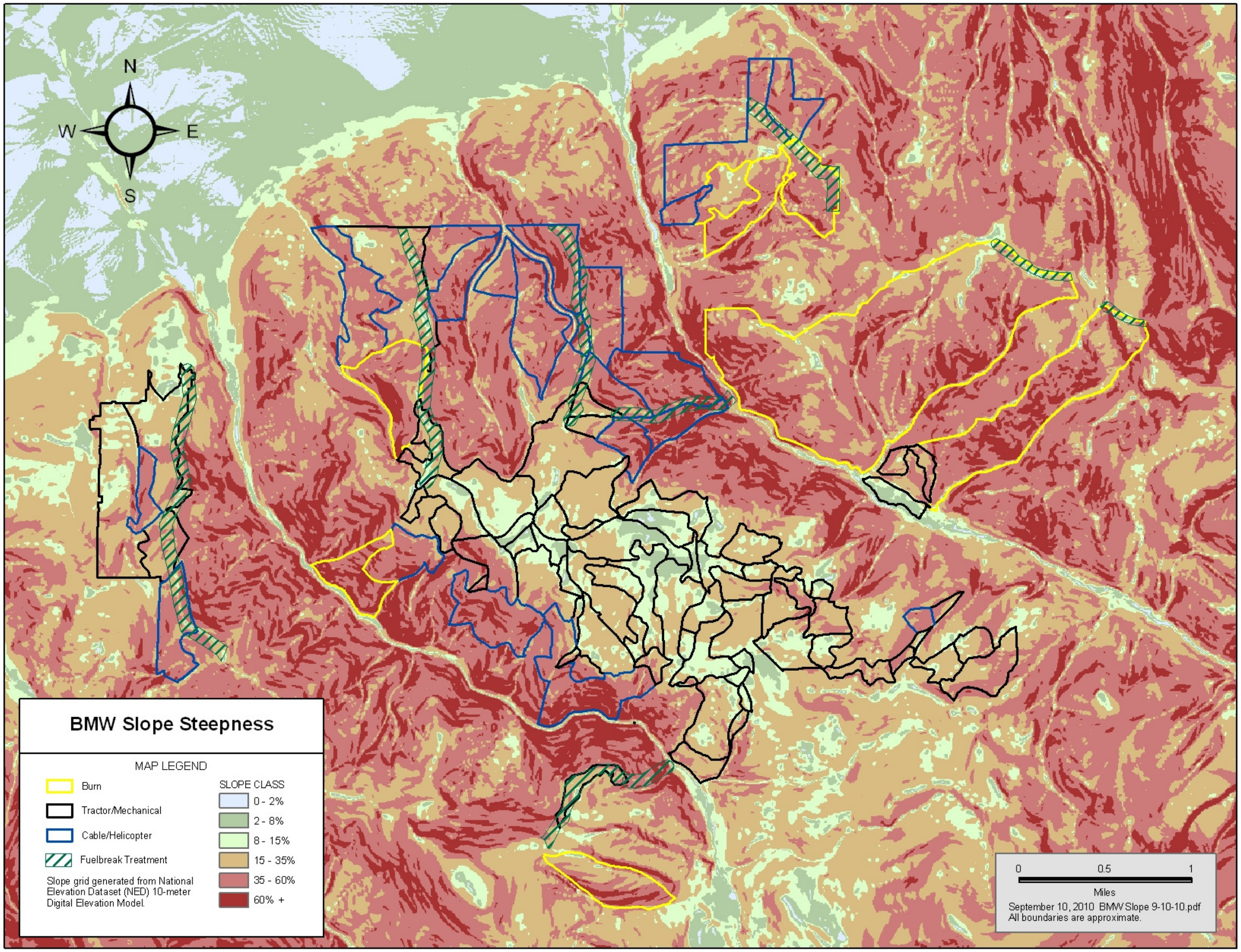
Topographic Features

The Soil Survey of the Gallatin National Forest provides very general characterization of slope steepness within map units because only four slope classes are identified: 0-10%, 5-20%, 10-45%, and 45-70%. Use of slope data from the Soil Survey does not provide accurate enough information about the distribution of slopes within map unit delineations for analysis. Figure 4 presents the results of terrain analysis for slope steepness for the project area with relative comparison to treatment units in Alternative 6. This approach will be used for all subsequent slope related soil-landscape analyses in the Bozeman Municipal Watershed area. Figure 4 clearly illustrates the somewhat unique, bedrock floored, rolling to moderately steep, mountain top area within the center of Bozeman Municipal Watershed.

Treatment units superimposed over terrain model results illustrate how potential tractor harvest units occur in less steeply sloping areas. It is Forest policy that tractor harvesting will not occur on sustained slopes greater than 35%. Hand thinning would be used in small diameter stands with consistently steep (>35%) slopes.

The area of Bozeman's Municipal Watershed ranges in elevation from approximately 5,400 feet, where Bozeman Creek leaves the Forest, up to 7,300 feet at the highest points along the ridge, East of Hyalite Creek. The project area as a whole, trends to the north but aspects of individual treatment units vary widely. As a result, environmental conditions of temperature and effective precipitation also vary widely among treatment units. These differences are reflected by variations in the degree and type of soil development found on different slopes, different aspects, and at different elevations. Coarse soil textures and abundant rock fragments will be constant throughout areas with predominantly coarse-grained, hard

Figure 4. Terrain analysis of slope steepness in the BMW area relative to treatment units for Alternative 6.



bedrock, parent material. Despite similar soil textures, however, a high degree of variability exists in soils of the area.

Variations in soils related to topographic factors are partly due to differences in site stability that influence soil erosion and deposition processes. They also relate to soil climate and the interaction between soil climate and plant communities. Most soils in this area would be classified as having a cryic soil temperature regime (i.e.: too cold for agricultural crops). Steep, south facing, aspects are both warmer and drier. These slopes have a frigid soil temperature regime, indicating warmer soil temperatures during much of the growing season which is responsible for the distinct differences in plant community types on south versus north slopes.

Mean annual precipitation within the BMW project area is estimated to range from 25 to 40 inches (Mark Story, GNF Hydrologist, personal communication). The range in effective precipitation, precipitation available for plant growth, is even greater as a result of topographic differences. For most of the BMW area, soils have an ustic soil moisture regime. The majority of precipitation comes in May and June despite the abundant snow during the winter. Soil moisture levels limit plant growth for a period of time at the end of the growing season, most years. Soils at higher elevation, especially on north aspects may have an udic soil moisture regime where soil moisture is not limiting plant growth at any period during the growing season of most years. Wet soils with “aquic” soil moisture conditions are generally associated with alder thickets, which most often exist on north aspects. Soils in this Bozeman Municipal Watershed area are relatively young due to active mountain building. Soil development in general is limited in this area. As noted previously, rock type plays a dominant role in determining basic soil properties such as soil texture, the amount and type of rock fragments, and soil pH. The addition of volcanic ash and other eolian material has beneficially influenced surface soil properties on stable sites in less steeply sloping areas and on heavily vegetated north aspects. Forest productivity in general has been enhanced somewhat by this deposition. Overall, however, the forest productivity in the Bozeman Municipal Watershed area is limited by cold soil temperatures, abundant rock fragments in soils, and droughty soil conditions that occur during the late summer of most years.

Applicable Laws, Regulations, Policy and Forest Plan and Travel Plan Direction

Land Productivity

The Sustained-Yield Act refers to “…coordinated management of resources without impairment of the productivity of the land”. The Forest and Rangeland Renewable Resources Act directly refers to the maintenance of productivity of the land and “specifies that substantial and permanent impairment of productivity must be avoided”. Standards in Forest Plan for the Gallatin National Forest indicate that “All management practices will be designed or modified as necessary to maintain land productivity and protect beneficial uses”.

Soil Quality

The Forest Service has often used soil quality as a surrogate measure for predicting potential reductions in land productivity on Forest Service lands. While it is easy to tell when land productivity has been reduced due to serious degradation of the soil resource, it is extremely difficult to say, that for every instance and every land use, productivity has been significantly reduced or improved when specific soil quality thresholds have been passed. This becomes increasingly true when surrogate measures are used as indicators of soil quality. The relationship between soil quality and productivity is general. For example, soil compaction is one measure used to indicate reduced soil quality.

Chapter 2550 – Soil Management: R-1 Supplement

The R-1 Supplement 2500-99-1 to FSM 2500 – Watershed and Air Management *(Effective 11/12/1999)* provides guidance for Region One on how National Forest System Lands should be managed "without permanent impairment of land productivity and to maintain or improve soil quality". Soil quality is defined in the R-1 Supplement, which also includes the Region wide standard for not creating "detrimental soil conditions" on more than 15 percent of an activity area. General guidelines for determining detrimental soil disturbance were also provided in the R-1 supplement. These guidelines have recently been defined more precisely for the Gallatin National Forest (Keck 2010) so they can be applied consistently in the field and so the identification of detrimental soil disturbance on the Gallatin National Forest is more closely aligned to observable reductions in soil productivity based on local soil conditions.

Gallatin National Forest Plan

Guidance relative to soils in the Forest Plan (USFS-GNF 1987) includes provisions that "best management practices" will be used to mitigate impacts occurring to the watershed from land use activities (p. II-5). An "adequate nutrient pool" shall be maintained in the soil to support long-term site productivity through the "retention of topsoil and soil organisms" (p. II-21). The Forest Soil Survey will be used as a part of the "resource area analysis" (p. II-23). "All management practices will be designed or modified as necessary to maintain land productivity… (p. II-24) "Treatment of natural fuel accumulations to support hazard fuel reduction goals will be continued (p. II-28).

Methodology for Analysis

Basic Soil Resource Information

Information about basic soil resources in the Bozeman Municipal Watershed area has been gathered from a number of sources. As directed by the Forest Plan, the Soil Survey of the Gallatin National Forest, Montana (USDA 1996) provided the starting point for assessments of soil resources in this area with broad general characterizations about local landforms, plant communities, and geologic materials in the area. Data in the Soil Survey have been enhanced by field reconnaissance, soil disturbance monitoring, and soil sampling within treatment units of the Bozeman Municipal Watershed by Tom Keck, current Soil Scientist for the Gallatin National Forest. Initial field reconnaissance of the entire area was followed-up by extensive field sampling and soil monitoring in selected treatment units from late August through mid-October of 2010.

All soil monitoring analyses included examination of shallow soil pits (10-12 inch deep) at each sample point along transects. This was done to verify soil surface horizon conditions at all sample point locations, as well as to collect valuable data about the distribution of soil properties in the area. Surface and near-surface soil attributes observed include soil texture, type and amount of rock fragments, evidence of soil compaction, dry or moist soil consistency, soil structure, rooting patterns, soil porosity, surface stoniness, forest floor depth, the type of surface horizons present, and any other unique features of the soil. Data on landscape attributes such as landform, plant community information, slope steepness, evidence of past logging, the occurrence and type of bedrock (if present), as well as any unique features were collected at specified intervals.

Additional references consulted to assess basic soil resources included Geologic Maps of the Bozeman 30' by 60' Quadrangle (Vuke, et.al., 2002) and the Livingston 30' by 60' Quadrangle (Berg, et.al., 2000), National Agricultural Imagery (NAIP) from 2009, and topographic maps of the area. All of the above sources of information have been used to help interpret the unique story of soils in the BMW project area and how they relate to natural resources of the area. Of special interest for the Bozeman Municipal Watershed is understanding the inherent susceptibility and resistance of soils in this area to different types of detrimental soil disturbance.

Detrimental Soil Disturbance and Past Timber Harvests

The R-1 Supplement (No. 2500-99-1) to FSM 2500 (USFS-R1 1999) states that the assessment of prior disturbances relates to detrimental soil conditions “from prior activities”. Thus, disturbances due to natural occurrences such as game trails or tree blowdowns are not counted towards the 15 percent maximum DSD standard. Disturbances due to other human activities are counted if the soil disturbance is significant enough to be considered detrimental. Potential sources of detrimental soil disturbance include but are not limited to: ATV use, cattle grazing, timber harvesting, and prescribed burning (USFS-R1 2009). Impacts from all of the above are considered in assessing DSD levels during field monitoring.

Past timber harvests occurred in and around the Bozeman Municipal Watershed project area. Figure 5 provides an index showing the orientation and overlap of Past Timber Harvest maps. Figures 6, 7, and 8 are individual maps with the locations of past timber harvests in the project area shown by harvest type and harvest age, relative to proposed treatment unit boundaries for Alternative 6. Treatment unit configuration in Alternative 6 is very similar to the other alternatives. Specific treatment boundaries vary among alternatives, although individual units remain in the same general location. As a result, these data provide a general picture of past harvest relative to all of the alternatives, but the specific amount of past harvest within individual treatment units may vary among Alternatives.

Tables 15 and 16 show in tabular fashion the same data presented in the past timber harvest maps (Figures 6-8), relative to the extent and distribution of past harvesting activity in proposed treatment units for Alternative 6. Data for all treatment units are presented in Table 15. Subunits slated for thinning in small diameter stands were lumped into a single Treatment Unit (999) in Alternative 6. Table 16 contains the summary results for Unit 999. Similar tables have been prepared for Alternatives 2 through 5. Alternative 1, the no action alternative, does not have treatment units. The majority of acres in Unit 999 (Alternative 6) originated from Unit 32 and Unit 33 in the earlier alternatives.

Table 16 shows the same type of tabular data as Table 15 for subunits of Unit 999. There are a total of 42 subunits or 42 separate timber stands within Treatment Unit 999. These are numbered from 99a to 99pp. Although the same general thinning strategy will be applied to all subunits, there is a variation in the past timber harvest activity among stands. The average proportion of area harvested per subunit in 999 equals 60%. This compares to 7.3% as the average proportion of area harvested per unit for the rest of the Treatment Units.

The proportion of area previously harvested ranges from no past harvest to 100% harvested. Prior detrimental soil disturbance in forest stands varies by both the type and extent of timber

Figure 5. Tile index for past harvest maps covering the Bozeman Municipal Watershed project area.

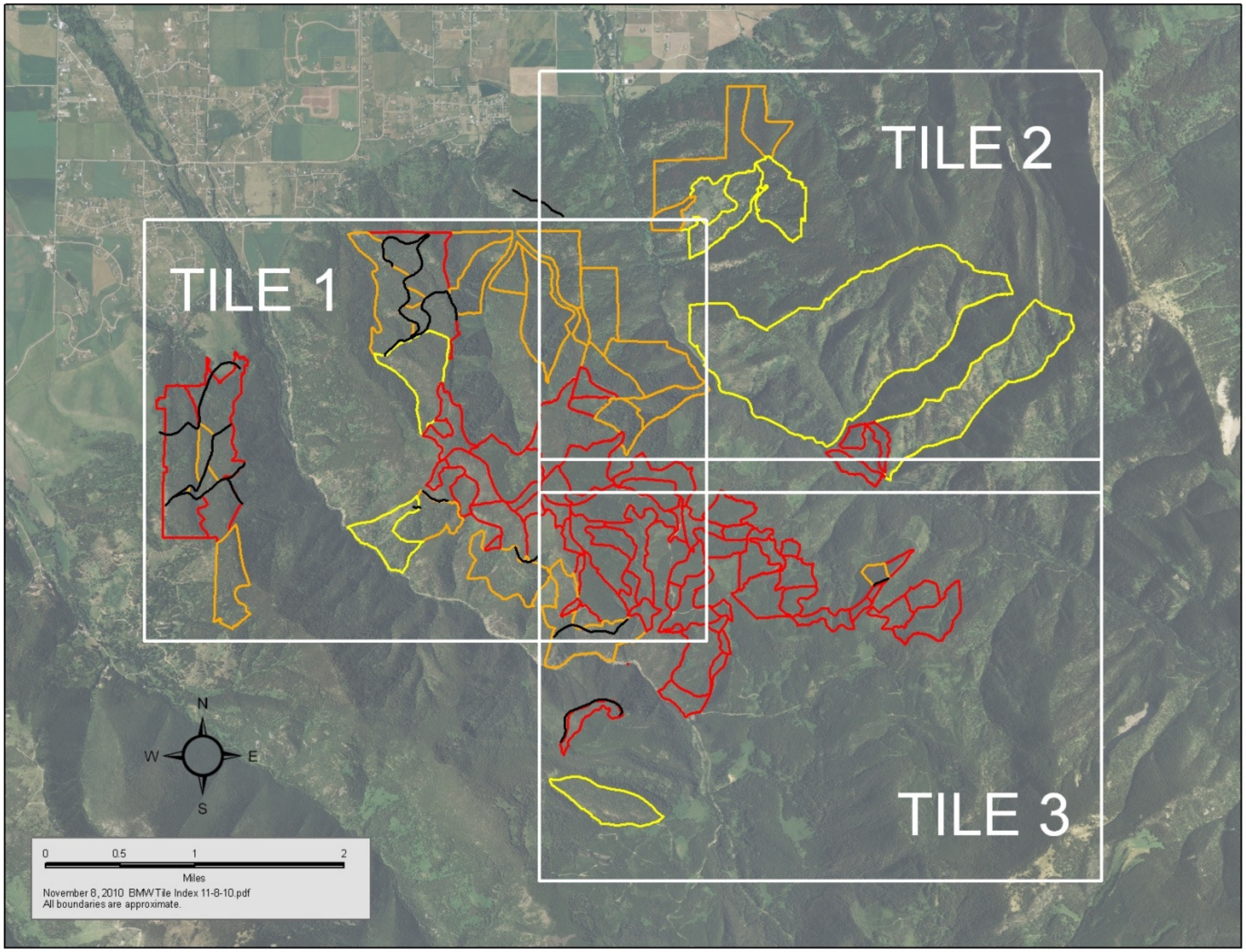


Figure 6. Treatment Unit boundaries and past timber harvests for western portion of the Bozeman Municipal Watershed project area.

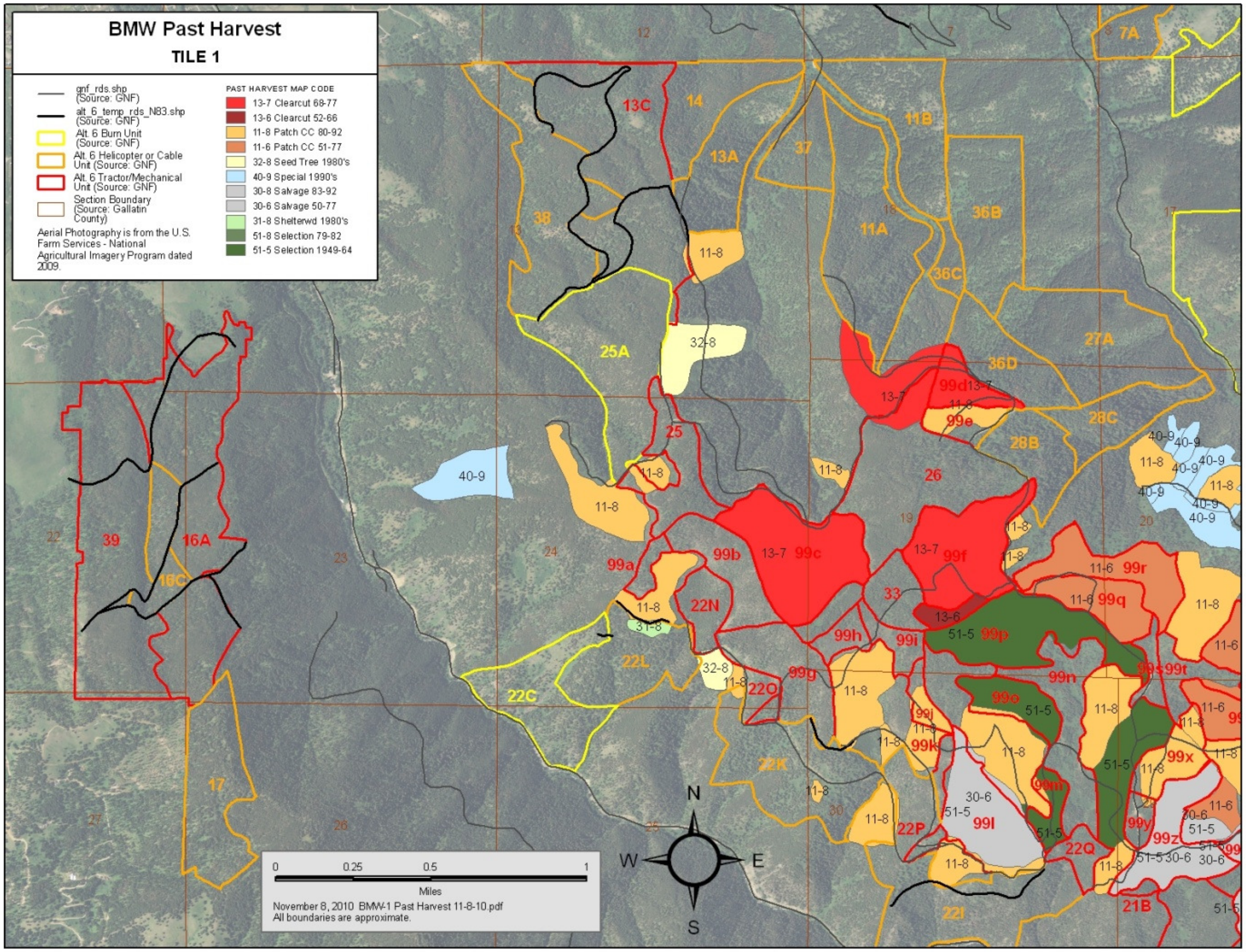


Figure 7. Treatment Unit boundaries and past timber harvests for the northeast portion of the Bozeman Municipal Watershed project area.

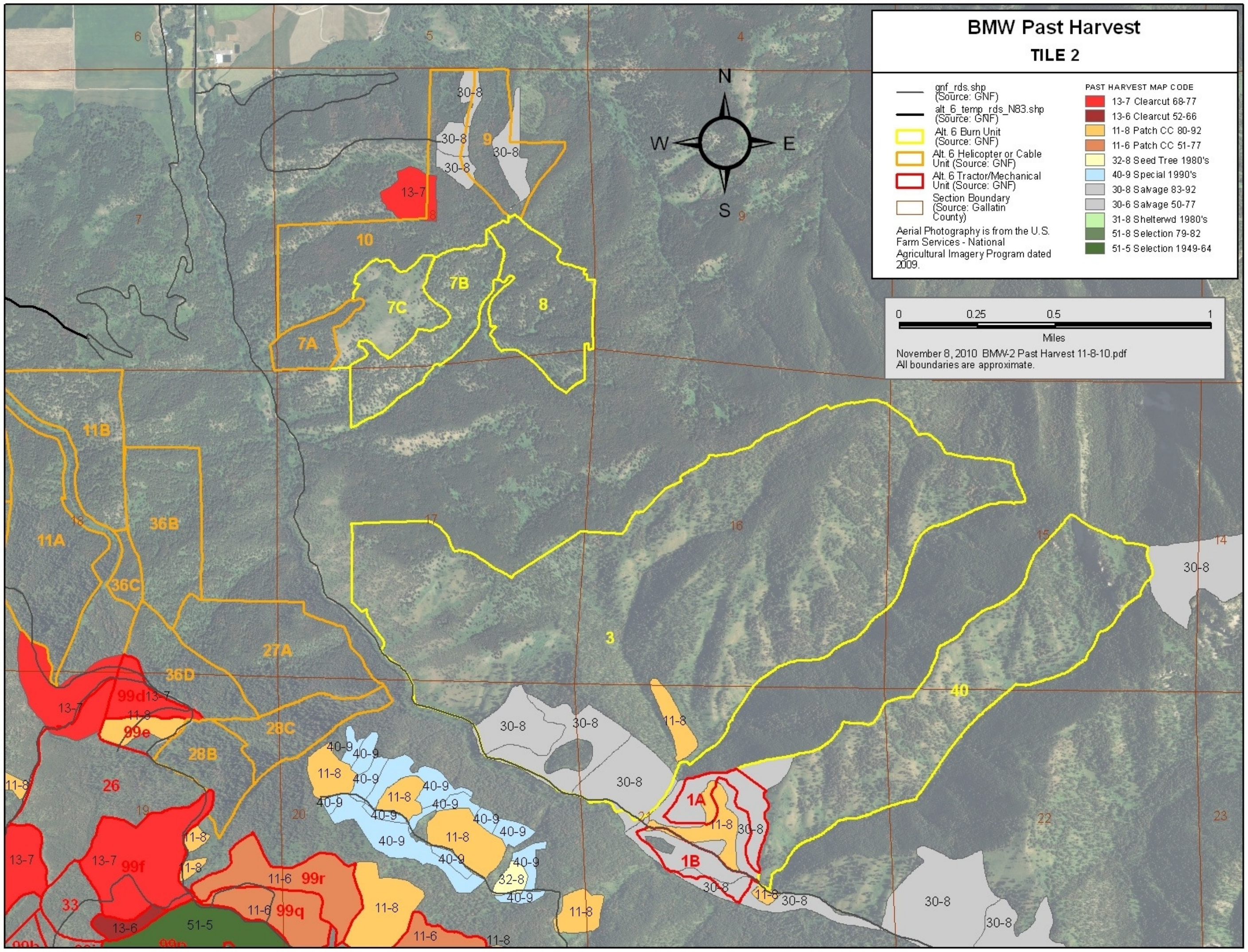


Figure 8. Treatment Unit boundaries and past timber harvests for the southeast portion of the Bozeman Municipal Watershed project area.

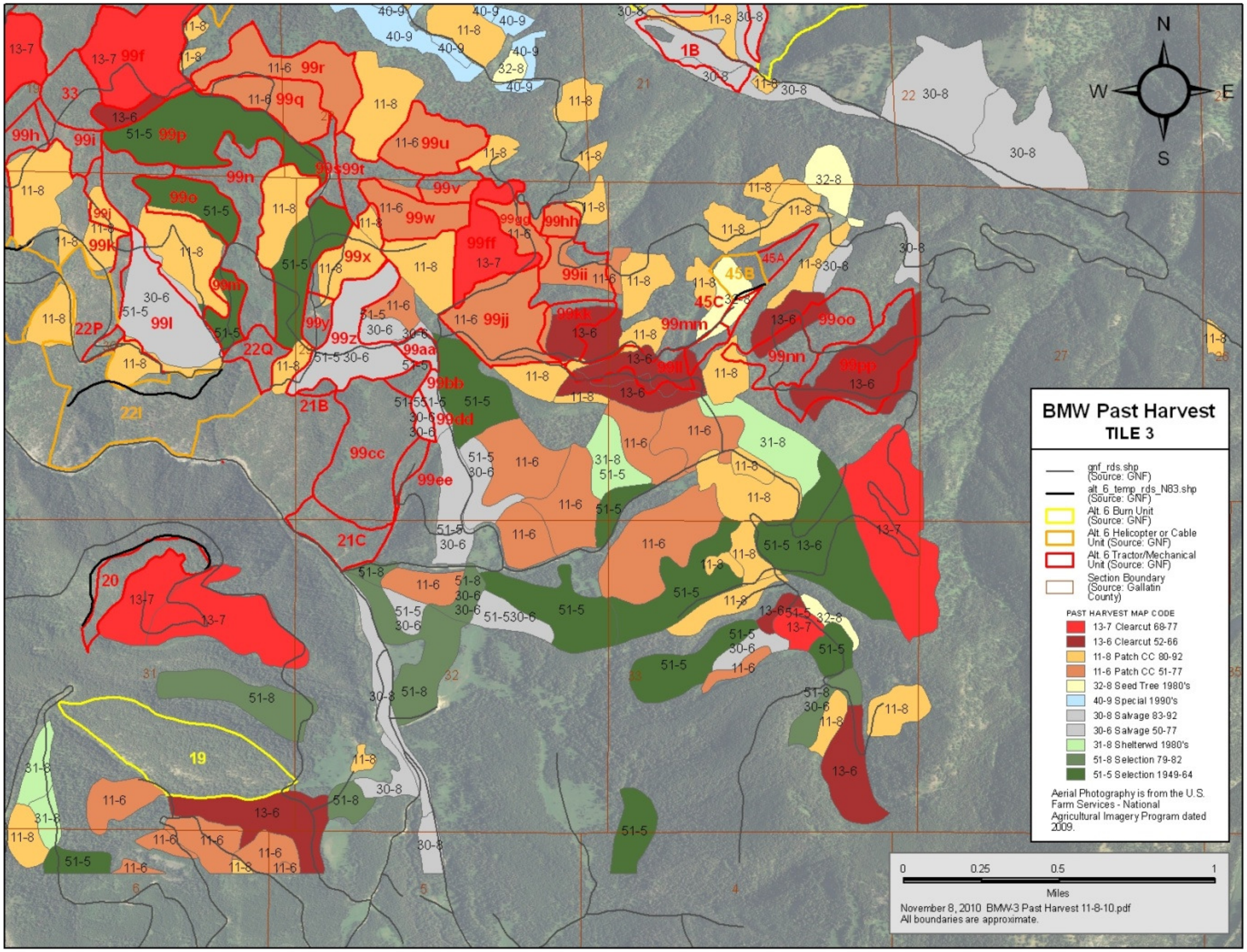


Table 15. Acreage and previous timber harvest data by treatment unit in Alternative 6.

Treatment Unit	Acres	Past Harvest		Treatment Unit	Acres	Past Harvest	
		Type	Approx Area %			Type	Approx. Area %
1A	25.3	Patch CC	10%	22L	57.8	Shelter wood	8%
1B	20.7	Salvage	90%	22N	20.5	none	---
3	876.3	Salvage	10%	22O	3.2	none	---
7A	21.2	none	---	22P	3.7	none	---
7B	68.3	none	---	22Q	12.6	none	---
7C	48.0	none	---	25	39.5	none	---
8	79.5	none	---	25A	101.6	none	---
9	51.1	Salvage	30%	26	103.3	Clearcut	15%
10	128.0	Salvage	10%	27A	98.8	none	---
11A	104.8	none	---	28B	37.9	none	---
11B	70.3	none	---	28C	40.0	none	---
13A	57.8	none	---	33	21.8	none	---
13C	147.5	none	---	36B	74.3	none	---
14	49.8	none	---	36C	10.9	none	---
16A	148.8	none	---	36D	46.3	none	---
16C	29.0	none	---	37	31.1	none	---
17	68.5	none	---	38	103.5	none	---
19	82.4	none	---	39	150.1	none	---
20	23.6	none	---	40	265.6	Salvage	5%
21B	2.4	none	---	45A	7.8	none	---
21C	23.8	none	---	45B	11.8	Seed Tree	60%
22C	63.0	none	---	45C	3.7	Seed Tree	100%
22I	119.6	none	---	999	1,117.0	Variable	68%
22K	88.5	Patch CC	5%				

Table 16. Acreage and previous timber harvest data for subunits in Treatment Unit 999 of Alternative 6.

Treat-ment Unit	Acres	Past Harvest		Treatment Unit	Acres	Past Harvest	
		Type	Approx Area %			Type	Approx Area %
99a	7.9	none	---	99v	11.2	Patch CC	50%
99b	37.0	none	---	99w	25.2	Patch CC	100%
99c	76.6	Clearcut	100%	99x	24.4	Patch CC	90%
99d	18.1	Clearcut	100%	99y	8.9	Patch CC	10%
99e	15.9	Patch CC	70%	99z	44.4	Salvage	100%
99f	62.7	Clearcut	100%	99aa	6.5	Salvage	100%
99g	46.9	none	---	99bb	5.4	none	---
99h	11.2	none	---	99cc	66.5	none	---
99i	13.4	none	---	99dd	4.9	Salvage	100%
99j	9.3	Patch CC	70%	99ee	6.8	none	---
99k	5.8	none	---	99ff	34.4	Clearcut	100%
99l	51.8	Salvage	100%	99gg	13.0	Patch CC	100%
99m	13.5	Selection	100%	99hh	7.3	Patch CC	100%
99n	50.2	none	---	99ii	26.1	Patch CC	50%
99o	24.6	Selection	100%	99jj	46.8	Patch CC	100%
99p	65.6	Selection	100%	99kk	18.9	Clearcut	100%
99q	30.3	Patch CC	100%	99ll	20.7	Clearcut	100%
99r	42.0	Patch CC	100%	99mm	6.2	Seed Tree	20%
99s	9.4	none	---	99nn	21.5	Clearcut	15%
99t	20.6	Patch CC	10%	99oo	21	Clearcut	10%
99u	31.4	Patch CC	100%	99pp	52.9	Clearcut	100%

harvesting in a stand. One half of all subunits in Unit 999 had previous timber harvests in 100% of the area. Average percent acres harvested in Unit 999 equals 68%; which means 68% of the area within Unit 999 has had previous timber harvesting of one type while in the rest of the treatment units, less than 10% of the total area has previously been harvested.

Field sampling in 2010 confirmed past disturbance in stands with prior timber harvesting by either clearcutting or partial overstory removal methods. The majority of that disturbance, however, does not meet criteria for detrimental soil. Repeated field observations of suitable forest floor depths and underlying mineral soil layers with friable to very friable soil consistence, granular structure, and abundant roots supports the finding that detrimental soil disturbance did not exist at the majority of sites sampled along transects. Nor was there any discernable change in site productivity except when recognizable evidence of DSD was present in the soil. This conclusion was supported by the Regional Soil Scientist for the Northern Region of the Forest Service, she concurred with current field verified estimates after assisting in soil monitoring within the core BMW area (Meredith Webster-personal communication 9/22/10). At the request of the Forest, the Northern Region Soil Scientist participated in soil monitoring and data collection because of the difference in estimates from the analysis in the FEIS 2010. This measure was intended to make sure sampling was accurate and according to established procedures.

The current estimate of existing detrimental soil disturbance differs from the previous estimate in the FEIS because the current analysis is based on extensive field sampling and monitoring from the proposed treatment units; while the previous analysis was based on visual monitoring but little to no field sampling from the project area.

Stratification of Activity Areas

The Region 1 Approach to Soils NEPA Analysis for Detrimental Soil Disturbance In Forested Areas - Technical Guide states that in large projects where treatment units cover hundreds of acres, it is acceptable to "stratify the activity areas by soil and past activity" and then "collect the appropriate level of data in a *sampling* of the activity areas in each stratification category"(USFS-R1 2009).

The predominant soil types in core BMW areas, including those areas with past timber harvests, are consistent in terms of basic soil properties such as soil texture, amount of rock fragments, and drainage class. Variation in timber harvest history was used as the basis for stratifying treatment units to establish initial soil disturbance levels for BMW.

Criteria used was based on past harvest differences across the area like the the degree of overstory removal in portions harvested and how much area within the treatment unit was harvested. Four classes were established with respect to the degree of overstory removal: 1 - Extensive overstory removal (clearcuts, patch clearcut, and seed tree harvests), 2 - Partial overstory removal (shelterwood, salvage/sanitation , and special cuts), 3 - Limited overstory removal (single tree and group selection harvests), and 4 - no past harvesting. Consideration was given at the start to using the age of past harvest (see past timber harvest maps) as criteria. Initial field assessments, however, did not indicate that age since past harvest in the BMW area was an important differentiating criteria. This is probably due to the fact that the youngest cut stands in the area are already close to 20 years old.

Proportion of area previously harvested was split into: high (70-100%), medium (15-70%), and low (<15%) categories. For the purpose of selecting field monitoring sites, a treatment unit could be dropped to a lower overstory removal class if only a part of the unit was harvested. This was not a significant factor, however, since there were plenty of subunits of 999 where the majority of area was harvested by a single harvest type. These units were targeted for soil monitoring because the data would not be confounded by within unit variations in past harvest type and because they had the greatest potential for having prior detrimental disturbance.

Table 17 shows the number of treatment units and subunits in each past harvest class for Alternative 6. The majority of past harvesting has occurred in the "small diameter thinning stands" which have been lumped together into analysis unit 999 in Alternative 6. In previous alternatives, most of these stands were included with Treatment Units 32 and 33. Subunits within analysis unit 999 have a wide range in type and intensity of past timber harvesting. Overall Treatment Unit 999 fits within the partial overstory removal class, yet 17 subunits are in the extensive overstory removal class. Only one treatment unit within Alternative 6 (45C) fits within the extensive past overstory removal class. This Unit encompasses only 3.7 acreas but is slated for ground based mechancial harvest in Alternative 6.

Table 17. Number of treatment units or subunits by past harvest intensity class for Alternative 6.

Past Harvest Class	#Treatment Units	#999 Subunits
	Total =47	Total=42
Extensive overstory removal	1	17
Partial overstory removal	2	8
Limited overstory removal	8	6
No previous harvesting noted	35	11

Soil Monitoring

Soil monitoring conducted in the Bozeman Municipal Watershed area during 2010 utilized the Forest Soil Disturbance Monitoring Protocol developed by Page-Dumroese and others (2009a and 2009b). This protocol assesses soil disturbance levels based on six indicators of soil health: soil compaction, rutting/smearing, topsoil displacement, burning, surface erosion, and soil mass movement. Most of the detailed soil monitoring was focused on sampling transects through those treatment units or sub-units with the highest likelihood for having high, pre-existing, detrimental soil disturbance levels. Areas of potentially high, detrimental soil disturbance were identified based on the the extent and type of past timber harvesting and proximity to heavy use areas for dispersed recreation.

Stand conditions, past timber harvest activity, and predicted levels of detrimental soil disturbance along with the likelihood that proposed treatments would create additional

DSD all contributed to determining the intensity of field sampling required for each treatment unit. Treatment units with no visible disturbance, based on activity records, aerial photos or other sources required just a site visit/walk through to verify conditions (USFS-R1 2009). Other areas with just a minimal amount of past harvest activity or minimal disturbance required only a traverse through the unit. Guidance in this regard is provided in the Region 1 Approach to Soils NEPA Analysis Regarding Detrimental Soil Disturbance in Forested Areas (USFS-R1 2009).

Soil monitoring transects using the National Soil Disturbance Monitoring Protocol (Page-Dumroese et. al.2009a and 2009b) are the highest level of assessment for determining dispersed DSD conditions. For those treatment units where the use of a transect was warranted, some scouting was often required prior to initiation of soil monitoring. Initial scouting was used to determine the orientation and boundaries of units to be monitored relative to landscape features and available imagery. Once oriented, a starting point for the transect was selected on the imagery based on a known map point that could be readily identified on the ground.

Transects in a given treatment unit were a series of interconnected transect segments. The segments were drawn in the field on 1:24,000 aerial photo/field maps prior to the start of soil monitoring and located without regard to field conditions. Transect spacing was based on obtaining good spatial coverage of the treatment unit or subunit and adequate separation between samples. Spacing between sample points was calculated based on total transect length and the approximate number of sample points needed for each transect segment. Estimates were based on map measurements taken in the field. Using the above, pre-determined, systematic sampling scheme minimizes potential sample bias while ensuring adequate sample spacing and good sample coverage for the area of interest. These steps are necessary for maintaining a sound statistical basis in estimating the level of detrimental soil disturbance DSD (Rice 1988).

Underlying assumptions of the data for making statistical inference are that all data points are independent, i.e.: not spatially correlated; that the level or occurance of detrimental disturbance is identically distributed throughout the treatment unit; and that sample points are located without bias. The first two criteria are most often abbreviated to “independent and identically distributed” or i.i.d. (Rice 1988). It should be noted that even though field procedures used are based on the Forest Soil Disturbance Monitoring Protocol, which includes multiple variables, the single objective of this analysis from a NEPA perspective is to determine the approximate level of one variable, detrimental soil disturbance, relative to the 15% standard.

Soil monitoring in many instances is focused on timber harvesting disturbances. The monitoring data itself, however, includes any activity-related disturbance regardless of source. Detrimental disturbances from cattle grazing, off-road vehicle use, firewood cutting, target shooting, or any other user-created soil disturbances are all included in the measurement of detrimental soil disturbance inside treatment units. System roads, those roads designated as nessessary for the long-term management of the Forest, are not included in the determination of detrimental soil disturbance levels.

Additional Field Data

To help ensure the accuracy of current monitoring results, a shallow, 12 inch, test pit was dug at each stop along the soil monitoring transects. Surface soil horizons at each sample location were examined for soil texture, amount of rock fragments, soil structure, moist or dry consistence (depends on current field condition), the abundance and distribution of roots, evidence of soil compaction, and any other soil properties of interest. This enhancement to the basic soil monitoring protocol takes more time but removes much of the guesswork associated with determining whether detrimental soil disturbance is present or not.

Multiple goals are served by assessing multiple surface and near-surface soil properties at each sample site as well as collecting auxillary resource data. Foremost is ensuring the quality of field observations with regard to accurately measuring the level of detrimental soil disturbance in treatment units. The additional data also helps explain why certain types and levels of detrimental disturbance are present or in their absence, why they are not present. This provides a mechanism for appropriately transferring soil monitoring information learned at one location to other environmentally similar situations. It also establishes essential baseline data for tailoring remediation actions needed to site specific conditions.

GPS coordinates were recorded for all sample points. Other auxillary data that were collected at specified sites include plant community data (overstory, understory, and reproduction or mid-level canopy), evidence of past harvest activity, surface stoniness, slope steepness, surface soil textures, and approximate clay contents. These factors are useful for planning remediation actions as well as for making other site management decisions. The Gallatin National Forest has initiated work on project level updates to improve the existing Soil Survey.

Areas of Concentrated DSD

Where reasonable, concentrated detrimental soil disturbances, such as those associated with old, unreclaimed, temporary roads, gravel pits, or user created two-tracks, can be measured directly. This approach provides the greatest accuracy for assessing such disturbances so long as their occurrence and boundaries are readily apparent on the ground and/or on aerial imagery. Concentrated disturbances may be linear, such as along temporary road corridors or non-linear. In either case, these disturbances are spatially correlated, i.e.: not spatially independent, so may not be accurately accounted for by randomly located transects.

In measuring concentrated disturbances, the measured area of disturbance is multiplied by the proportion of area detrimentally disturbed to determine the areal extent of detrimental soil disturbance. In some instances, the proportion of detrimental soil disturbance has been assumed to be 100% based on field observations. In other instances, direct field measurements were made to determine the proportion of area within a disturbance that was detrimentally disturbed by running a series of transects across the disturbance at specified intervals.

Field measurements of road length and width of disturbance were made on several partially closed roads within BMW. In a number of other instances, the aerial extent of known concentrated disturbances was measured directly from the 1:24,000 scale, base-map imagery. All sites measured in this manner were observed in the field ahead of time and could be readily identified on the imagery. It was assumed, based on limited field observations, that the proportion of DSD in readily identified bare areas on the imagery was 100%. The second approach (imagery) would over estimate the level of detrimental soil disturbance resulting in high estimates. Areas of concentrated disturbance, when measured separately, were then removed from the base area considered when determining levels of dispersed DSD in treatment units.

Results from both concentrated and dispersed DSD levels are combined to calculate the total level of DSD for a treatment unit.

$$\text{Total } DSD_{Unit} = DSD_{Dispersed} + DSD_{Conc.}$$

As with dispersed DSD levels, only those areas within treatment boundaries are included in the total DSD calculations.

Mitigation of Detrimental Soil Disturbance

The major sources of long term, detrimental soil disturbance associated with timber sales are temporary roads and landings. This assumes that the timber sale is reasonably well laid out and that soil erosion has been held in check by the use of appropriate Best Management Practices. The primary emphasis of the Gallatin National Forest's soil mitigation standards is to minimize the long term detrimental soil disturbance associated with temporary roads and landings.

Temporary Roads

Many factors can affect the actual level of detrimental soil disturbance created at landings or along temporary roads. The same factors determine both the suitabilty and effectiveness of different mitigation procedures. For temporary roads, some blading of these roads would occur at the start of harvesting and that trees along the road corridor would be tipped over and removed, root ball and all. A certain amount of topsoil displacement and mixing with underlying subsoil would be inevitable, although not all of the topsoil resource would be lost. Much of it would just be re-distributed to the downslope side of the road. Soil compaction and loss of organic substrates would also be issues along temporary roads. However, the major long term source of DSD along temporary roads would be loss of topsoil.

Factors affecting the level of DSD created along temporary roads include steepness of the terrain, soil texture and the amount of rock fragments in both the topsoil and underlying subsoil horizons, as well as the depth of blading. Within the constraints of suitable road construction standards, the depth of blading should be minimized to the extent practical during road construction. This practice would preserve topsoil and maintain soil productivity within the road corridor over the long term. See Gallatin National Forest BMP's in Appendix A of the SFEIS.

The degree of lost soil productivity in the road corridor would most often depend on differences in soil properties between the topsoil layers and underlying subsoil. If little difference exists in basic chemical and physical properties; either both are good, or both are poor, then changes in soil productivity would be limited. If there are dramatic differences in soil chemical and/or physical properties between topsoil and subsoil layers, the loss of topsoil layers would result in a significant loss of soil productivity. If the primary difference between topsoil and subsoil is in the amount of soil organic matter and organic substrates, then lost soil productivity may be significant at the start but would recover over time.

Soil mitigation measures for temporary roads on the Gallatin National Forest would take into consideration initial soil properties, terrain features, future uses of the road, and potential for noxious weed infestations. An additional consideration would be that the mitigation practice does not create any more additional disturbance than necessary.

Expected Mitigation Effectiveness (Temporary Roads)

Assumptions:

Average road width equals 14 feet and 100% of the road base would initially be detrimentally disturbed. Diversion of any water flowing down the road in areas of moderately sloping or steeper grades would be effectively accomplished by BMP's incorporated into the project design.

Sources of DSD include displacement and loss of topsoil along portions of the road, soil compaction, potential soil erosion due to rutting, and loss of soil organic matter and organic substrates.

Site conditions include coarse textured soil with variable soil depths; limited rock fragments in the surface soil layers, increasing with depth to abundant rock fragments in subsoil layers.

Table 18. Expected mitigation effectiveness of temporary roads 2 years and 5 years after mitigation completed. Estimates are based on detrimental soil disturbance criteria and personal observations made by the Soil Scientist for the Gallatin National Forest.

Mitigation	**Remediation Effectiveness****	
	2nd Year	**5th Year**
Ripping (6-8") and seeding*	30%	40%
Add slashing @ 10-15 tons/acre	40%	60%
Slashing alone	10%	20%

** Includes re-contouring where appropriate. **Remediation effectiveness refers to the extent DSD is expected to be reduced within the specified timeframe.*

Shallow ripping and seeding along temporary roads would break up compact hard pans formed during construction, re-establish vegetation along the road bed, and allow for water infiltration. Ripping would fill in depressions formed by rutting. Ripping along most temporary roads in the BMW would likely be limited to one or two passes with 2 to 3 ripping shanks due to abundant rock fragments in the subsoil. All of the above would enhance further natural recovery of the site by promoting effects of wetting and drying, freeze-thaw, the action of macro-invertebrates, water infiltration and accumulation of additional soil organic matter on the site.

Re-contouring would not be recommended in most areas of BMW due to abundant rock fragments in the subsoil. This procedure, in rocky (high rock fragment content) soils tends to concentrate rock fragments at the surface of recontoured soils, especially if recontouring is done when soils are dry. The concentration of rock fragments near the surface occurs through natural sorting as materials are moved off the road surface during road construction and again when soil materials are moved back onto the road during recontouring. Re-contouring can provide excellent results in heavier textured soils, soils with limited amounts of rock fragments, or soils with deep topsoil layers. Restricting use of decommissioned roads is a legitimate reason for re-contouring roads even at times when soil conditions are not favorable but should not be viewed as a soil mitigation practice in those instances but rather an access mitigation.

Slashing alone adds a ready source of organic substrates and coarse woody debris to the site, creates variable microsites for plant establishment, helps protect the soil from erosion, limits potential for ATV use of the road after mitigation, and also promotes natural recovery by enhancing the effects of wetting and drying, freeze-thaw, and the action of macro-invertebrates to break up dense layers in the soil. “Biological processes become more important to natural recovery of soil physical properties when the soil is covered with forest floor sufficient to protect roots and soil fauna in the surface horizons from mechanical disturbance and extremes of temperature and moisture” (Miller et. al. 2004).

The combination of ripping, seeding, and slashing enhances overall effectiveness. Natural recovery would continue to eliminate DSD over time so long as the road system has been properly planned and water erosion has been controlled. Replacement of the topsoil layer, however, would take a very long time. Improved soil moisture and soil temperature conditions would have variable effect but may compensate to some extent. Expected long term mitigation effectiveness for reducing DSD along temporary roads in a 20 year period is 70-80% given the site-specific conditions in the project area.

Landings with Burn Piles

In contrast to temporary roads, landings do not require cut and fill operations provided they are correctly sited. Selection of a relatively flat area is the prime consideration. Forested areas used for landings would likely have abundant stumps cut close to the ground but not removed. These would limit options for ripping during mitigation but would also limit the continuity of soil compaction on the landing. Abundant rock fragments in surface soil layers also reduce the overall level of soil compaction.

Landings located in open areas would not have stumps to either limit ripping options or limit the potential for severe soil compaction. In some instances, the presence of grassland vegetation in an area may indicate soil conditions that make these sites unsuitable for use as landings. Examples include: areas of shallow groundwater (wetland soils protected by Montana SMZ practices), heavy clay soil textures, or deep, dark topsoil layers indicating highly productive grassland sites. In many other instances, open areas in the forest may be ideally suited for locating landings.

Burning of large slash piles on a portion of the landing has the potential for creating detrimental soil disturbance immediately below the pile due to severe burning. In extreme cases, this could reduce long term productivity of the mineral soil resource itself due to changes associated with extremely high soil temperatures (Neary et al. 2005) Loss of organic substrates and coarse woody debris are the most obvious impacts beneath burn piles. These impacts would likely be temporary or transient and they can be mitigated. Unlike extreme wildfires, burned areas under slash piles are isolated from a water erosion standpoint because they are small areas surrounded by areas with organic substates and woody debris. While significant soil impacts occur at landings, the topsoil resource remains largely intact.

Expected Mitigation Effectiveness (Landings with Burn Piles)

Assumptions: The area disturbed equals approximately 1/2 acre per landing. Initial detrimental soil disturbance occurs over 90% of the area. Landing areas are relatively level and the diversion of any water flowing off the landing would be effectively accomplished by BMP's. Approximately ½ of the landing area would be covered by the burn pile, leaving the other half exposed for mitigation at the end of logging.

Major Sources of DSD include soil compaction; potential soil erosion due to rutting on strongly sloping grades; potential severe burning beneath the burn pile in the center of the landing.

Site conditions inlcude coarse textured soils with variable soil depths; limited amounts of rock fragments in surface soil layers, increasing with depth to abundant rock fragments in subsoil layers.

Table 19. Expected mitigation effectiveness of landing areas 2 years and 5 years after mitigation completed. Estimates are based on detrimental soil disturbance criteria and personal observations made by the Soil Scientist for the Gallatin National Forest.

Mitigation	**Remediation Effectiveness****	
	2nd Year	**5th Year**
Ripping (6-8") and seeding (1/2 area)	50% x 0.5 = 25%	40%
Add slashing @ 10-15 tons/acre	60% x 0.5 = 30% 20% x 0.5 = 10%	60%
Slashing alone	20% x 0.5 = 10% 20% x 0.5 = 10%	30%

***Remediation effectiveness refers to the extent DSD is expected to be reduced within the specified timeframe.*

Different portions of the landing would be treated separately. The portion of the landing beneath burn piles cannot be ripped because it is covered during the time when equipment is available. Exposed landing areas around the burn piles would be shallow ripped with only 2 or 3 shanks on the toolbar. This would limit the amount of rock fragments brought to the surface while providing sufficient disturbance to establish vegetation and facilitate water and air movement into the soil. If the area to be ripped has too many stumps or too many large rock fragments then remediation effectiveness would be reduced but for the same reason there would be less soil compaction overall.

It is recommended that burn piles be constructed more like mounds than consolidating them into steep sided piles. This would facilitate removal of some material from the margins of the pile by Forest Service personnel. Material would be used for slashing the area of the burn pile afterwards. The combination of ripping and seeding, along with slashing, would enhance overall effectiveness. Natural recovery would continue to eliminate the remaining DSD over time but evidence of burned slash piles would remain for an extended period. Long term remediation effectiveness (20 years) would likely be 90 to 95% provided the mineral soil resource remains intact.

Skid Trails

Skid trails have a much lower level of detrimental soil disturbance than either temporary roads or landings. They are also more likely to recover through natural processes over time provided adequate erosion control measures have been used. Reduced levels of material being removed in fuels treatments limits the number of trips that would be required along skid trails relative to standard clearcutting practices. This along with the presence of coarse textured soils would reduce the level of detrimental soil disturbance created during mechanical harvesting. The basic soil resource along skid trails would remain intact provided any potential soil erosion is controlled.

Assumptions: Average skid trail width is 10 feet. Forty percent of the skid trail width (beneath the tracks) would be detrimentally disturbed in coarse textured soils by the end of harvesting; severity of detrimental disturbance, where present, would be less than that found on temporary roads and landings.

Major Sources of DSD include soil compaction; possible soil erosion due to rutting on moderately steep grades.

Site conditions include coarse textured soils, limited rock fragments in surface horizons; increasing with depth to abundant rock fragments in subsoil horizons; variable soil depths.

Table 20. Expected mitigation effectiveness of skid trails 2 years and 5 years after mitigation completed. Estimates are based on detrimental soil disturbance criteria and personal observations made by the Soil Scientist for the Gallatin National Forest.

Mitigation	**Remediation Effectiveness****	
	2nd Year	**5th Year**
Slashing @ 10-15 tons/acre	30%	40%*
Add water control on steep slopes (>15%)	40%	60%
Water control on steep slopes alone	15%	25%

** See Assumptions. **Remediation effectiveness refers to the extent DSD is expected to be reduced within the specified timeframe.*

Long term effectivnesss of remediation plus natural recovery on skid trails would likely be 100% given site specific conditions in the project area.

Spatial boundary

The spatial boundary for direct and indirect soil effects is the actual treatment unit boundary for individual treatment units in the Bozeman Municipal Watershed Fuels Project. Assuming offsite erosion or deposition does not occur, productivity effects to soils are spatially static. Productivity in one location does not influence productivity in another location (USDA 2009). Therefore, the spatial limit for direct and indirect soil effects is the activity area.

The cumulative effects analysis boundary for soil disturbance in the Bozeman Municipal Watershed is a continuous boundary encompassing all lands within treatment units and interconnecting lands between treatment units including all temporary roads and landings. A cumulative effects analysis boundary map is in the project record. This boundary does not mean that soil monitoring needs to be conducted outside activity areas but does infer a need to look outside treatment boundaries to interconnecting areas when assessing cumulative effects. Cumulative effects analysis would take into account surrounding landscapes that are spatially connected to treatment units. The activity area for cumulative effects, to soil productivity (at a point), is the same as the activity area for direct and indirect effects for the same reasons stated previously. However, the detrimental soil disturbance standard can and should be applied at various scales, especially if the level of prior DSD immediately outside treatments units exceeds disturbance levels within treatment units as identified above.

Temporal boundary

Temporal bounds used in this analysis are 60 years backwards as remnant detrimental soil disturbance can still be found in some forest stands that were harvested up to 60 years earlier. The temporal bound forward is limited to 20 years which is well beyond the current planning horizon for Forest Service projects. It is impossible to predict future management actions that could affect the current project beyond 20 years out.

It is expected that the level of potential detrimental disturbance would be greatest immediately after the completion of harvesting. With mitigation measures, the level of disturbance would gradually decrease over the first 20 years until transitory detrimental effects on soil resources have been largely erased. This recovery could be due to a combination of influences of initial remediation efforts and natural recovery or due to natural recovery alone. Equilibrium should be reached by year 20, then only incremental improvements in the level of detrimental disturbance would be likely to occur.

Selected treatment areas where tractor harvesting equipment has been used would be monitored at 2 years and 5 years after harvesting is complete. By year five, it should be obvious whether the site has been improving, staying static, or degrading. Sampling at 5 years would determine whether additional mitigation measures are needed. Twenty years should define final conditions when the level of detrimental soil disturbance would stay relatively static provided no major disturbances occur.

EFFECTS ANALYSIS

Direct and Indirect Effect Common to All Alternatives

Detrimental soil disturbance (DSD) occurs when management activities, such as timber harvesting, cattle grazing, or recreational use, cause changes to the soil resource that significantly reduce soil quality to the extent that land productivity may be impaired beyond the activity period. Within the Bozeman Municipal Watershed, past timber harvesting is the primary cause of such disturbance. Recreational disturbances along the main Forest roads are most noticable but they represent only a small fraction of the disturbance attributable to past timber harvesting.

Three factors contribute to the level of DSD found in previously harvested forest stands. First, is the type of harvest that occurred, or more specifically the proportion of stand removed. Thus, clearcutting tends to create more disturbance than partial cutting, such as a shelterwood cut. A shelterwood harvest, in turn, would create more disturbance than a single tree selection cut. Of even greater importance to predicting harvest impacts is the method used to remove timber from the site. Use of tractors, rubber tired or tracked, creates the greatest level of soil disturbance followed by cable logging where the butt ends of logs are dragged along the ground surface. Skyline methods, using tractors for winter harvesting (under BMP defined conditions), and helicopter logging create limited to almost no DSD.

The last factor determining the amount of prior DSD in a stand is time. How much time has passed since the stand was harvested? Many of the surrogate measures used to measure DSD tend to decrease over time. Miller, et.al. (2004) refer to such impacts as "transient". Indicators of DSD that tend to decrease over time include: soil compaction, rutting, burning, and loss of organic matter and/or loss of coarse wood debris. In general, soil recovery in these instances is a one directional, linear function upward as disturbance conditions improve over time. The rate and degree to which soil recovers "naturally" depends on a number of interrelated factors. The most important factors include: the degree of disturbance, soil texture, soil temperature and moisture conditions, the amount of rock fragments in the soil, and the action of micro and macro-invertebrates.

Soil erosion, on the other hand, has the potential for getting progressively worse as denuded areas of freshly exposed soil result in increasingly greater soil erosion rates. On this trajectory, extensive degradation would be followed by healing only after a long period of time. Soil displacement falls somewhere between these two extremes. The direction the site goes depends on the severity of soil loss and the suitability of soil substrates.

Figures 6, 7, and 8, presented in the Methodology Section illustrate the amount and type of past timber harvests by treatment unit in Alternative 6 as well as subunits in analysis Unit 999. Tables 15 and 16 show the same data in tabular form. Only four treatment units are identified as having past timber harvest over a large portion of the unit. These are Units 1B with salvage harvesting over 90% of the unit, 45B and 45C with seed tree harvests covering 60% and 100% of the area, respectively, and the aggregated Unit 999 in which various types of past timber harvest have occurred over 68% of the area.

The combined acreage of Units 1B, 45B, and 45C is 41acres. In contrast, Unit 999 contains 1,117 acres subdivided into 42 individual sub-units. Unit 999 also contains nearly all of the acreage of past clearcutting in the proposed treatment units. This makes sense since Unit 999 is described as a partial thinning in small diameter stands, i.e.: stands that have been harvested previously. These results mirror the past harvest classification discussed in the Methodology section and presented in Table 17. Only one of the 47 treatment units in BMW Alternative 6 fit the criteria for past "extensive overstory removal" while 17 of the 42 subunits in Unit 999 meet this criteria. Unit 999 overall meets the criteria for "partial overstory removal".

Soil Monitoring Results

Table 21 summarizes field monitoring results for the individual subunits of Unit 999 for detrimental soil disturbance. The majority of soil monitoring data was collected in stands with the greatest likelihood for having prior DSD from past timber harvesting. These include subunits 99jj, 99c, 99q, 99r, 99f, and 99x. All of these subunits belong to Past Harvest Class 1, as 90 to 100 percent of the area in each subunit was previously clearcut.

All but one of the subunits sampled was previously harvested more than 35 years ago. While, numerous stands in the BMW area were clearcut between 1980 to 1992, the more recently harvested stands were, for the most part, avoided in laying out the current proposed treatment units. Subunit 99x was sampled specifically because it had been clearcut more recently than the other clearcut stands monitored in the proposed treatment units.

The sampling protocol used (Page-Dumroese et al. 2009a) provides for quantitative estimates based on the point sampling. At times, obvious areas of DSD were observed along transects at points not coinciding with sample locations. In this siutation, observational information about stand and site conditions along the entire transect length was useful for accurately interpreting results.

The highest levels of measured DSD (6.7%) were found in subunits 99jj and the combined sampling in subunits 99q and 99r. All of these units were previously harvested by patch clearcutting over the entire subunit. For each of these subunits, past harvesting took place more than 35 years ago.

Results presented in Table 21 provide information about past harvesting within each subunit sampled: number of transect data points, number of points identified as detrimentally disturbed, calculated percent DSD based on transect results, and the estimated true range in DSD within the subunit based on transect results and additional field observations within each stand. No prior activity related DSD was measured along transects in the salvage cut (99z) or selection cut (99p) subunits sampled, although some DSD was observed along the transect corridor in both of these subunits.

Table 21. Field results from detrimental soil disturbance monitoring by subunit.

Unit	Harvest Type	Harvest Age	Aerial Extent	Past Harvest Class†	Total Data Points	Total DSD Points	Calc. DSD	Est. Range
		Yrs.	%				%	%
99jj	Patch clearcut	35-60	100	1	30	2	6.7	4-8
99c	Clearcut	35-40	100	1	30	1	3.3%	2-5
99q 99r	Patch clearcut	35-60	100	1	30	2	6.7	4-8
99z	Salvage cut	35-60	100	2	31	0	0	1-3
99f	Clearcut	35-40	100	1	30	1	3.3	3-7

99p	Selection cut	45-60	100	3	14	0	0	0-1
99x	Patch clearcut	20-30	90	1	31	0	0	2-4

† Past harvest classes: 1 = extensive overstory removal, 2 = partial overstory removal, 3 = limited overstory removal, 4 = no previous harvesting.

Results above are summarized in Table 22 by past harvest class. Overall, there were 196 point locations sampled along transects in Unit 999. One hundred and fifty-one of these were in previously clearcut or patch clearcut stands, 31 were from a salvage cut area, and 14 from a low intensity transect in a stand previously harvested by selection cutting. Soil monitoring in clearcut stands yielded an overall average of 4% DSD. The estimated range in DSD for clearcut areas was 2 to 8% DSD with a central tendency around 4 to 5%. The lone salvage cut stand monitored had no DSD based on sample results. Field observations along the transect, however, indicate the level of DSD to be most likely in the 1 to 3 percent range with a central tendency of 2%.

Table 22. Summary of field results from detrimental soil disturbance monitoring by past harvest class.

Unit	Harvest Type	Harvest Age	Aerial Extent	Past Harvest Class	Total Data Points	Total DSD Points	Calc. DSD	Est. Range
		Yrs.	%				%	%
999	Patch Clearcut; & Clearcut	20-60	98	1	151	6	4.0	2-8
999	Salvage cut	35-60	100	2	31	0	0	1-3
999	Selection cut	45-60	100	3	14	0	0	0-2
999	All	20-60	---	all	196	6	3.1	2-5

A partial transect was monitored in subunit 99p. This stand had been harvested as a selection cut 45 to 60 years ago. Only 14 sample points were monitored along the transect. Of these, no sample locations were identified as having detrimental soil disturbance although some minor soil disturbance (disturbance class 1) existed at a number of sample locations. The remainder of this stand was assessed by a simple walk through. The estimated range in DSD for selection harvests based on these data and associated observations is 0 to 2 percent with a central tendency below one percent.

Levels of DSD observed for each past harvest class are partially a reflection of the predominance of coarse textured soils in the area. Near surface mineral soil layers that were sampled consistently had loamy sand to sandy loam soil textures. These soils are not prone to substantial soil compaction (Han et.al. 2006; Miller et.al. 2004; Keck, personal observations based on extensive soil sampling in reclaimed minesoils). Soil compaction, in the past, has been identified as the primary type of activity related to DSD in timber harvested areas of the Gallatin National Forest (Shovic and Birkland 1992; Shovic and Widner 1991). Field results from the current soil monitoring in subunits of the BMW agree with expected levels of DSD based on prior observations on the Gallatin Forest with soil textures similar to the project area.

Estimation of Prior DSD Levels

The above data are biased towards treatment units with the greatest potential for having high levels of pre-existing DSD in Unit 999 based on past timber harvest activity. Despite this, the overall calculated level of DSD in Unit 999 equals 3.1 percent. The estimated range in DSD is 2 to 5 percent with a central tendency around 3 to 4 percent. These values agree with field observations of the overall level of detrimental soil disturbance in Unit 999.

The above soil monitoring data combined with site observations were used to interpolate expected levels of pre-existing DSD based on past harvest data for all treatment units or subunits. Values used were modified slightly from measured values, as noted below, to cover past harvest types that were of limited occurrence in planned treatment units. A limited acreage of past seed tree harvests overlap proposed treatment units (Units 45B, 45C, and subunit 99mm). In general, seed tree harvests are expected to result in lower levels of DSD than clearcutting if other factors are equal. A pre-existing DSD level of 6%, prorated for the proportion of the treatment unit previously harvested, was assigned to the seed tree harvests, the same as clearcutting, because clearcutting represents the most similar harvest type for which there is sufficient soil monitoring data.

Past shelterwood harvests were similarly rare within proposed treatment units but did constitute a small proportion of treatment unit 22L. The shelterwood harvest type is expected to have a similar level of DSD as salvage harvesting so it was grouped with salvage harvesting. Because the under-sampled harvest type adds a certain degree of uncertainty, the DSD level associated with both salvage and shelterwood harvests as well as special cuts was raised to 3%.

Selection cut harvests were also rare within planned treatment units or subunits of BMW. These were assigned a predicted DSD level of 1%. Areas without prior timber harvesting were considered to have no detrimental soil disturbance based on field observations and the fact that only activity generated disturbances are included as DSD. These areas tend to not have road or trail access so additional sources of DSD, such as ATV use and target practice are also restricted.

Based on the above, available soil monitoring results were converted to predicted levels of DSD within treatment units by prorating the level of DSD based on the proportion harvested. Identifiable areas of concentrated detrimental soil disturbance, either measured in the field or measured on available imagery, are added to predicted levels of dispersed DSD in calculating total prior DSD levels. Determinations of prior DSD levels for all treatment units in Alternative 6 are presented in Table 23.

Table 23. Prior DSD calculations for all proposed treatment units in Alternative 6.

Tmt Unit	Past Harvest		Prior DSD (%)			Tmt. Unit	Past Harvest		Prior DSD (%)		
	Type	Area %	Disp.	Conc.	Total		Type	Area%	Disp.	Conc.	Total
1A	CC	10%	0.6	0	0.6	22L	SWD	10%	0.3	0	0.3
1B	Salvage	90%	2.7	0	2.7	22N	None	---	0	0	0
3	Salvage	10%	0.3	0	0.3	22O	None	---	0	0	0
7A	None	---	0	0	0	22P	None	---	0	0	0
7B	None	---	0	0	0	22Q	None	---	0	0	0
7C	None	---	0	0	0	25	None	---	0	0	0
8	None	---	0	0	0	25A	None	---	0	0	0
9	Salvage	30%	0.9	0	0.9	26	CC	15%	0.9	0	0.9
10	Salvage	10%	0.3	0	0.3	27A	None	---	0	0	0
11A	None	---	0	0	0	28B	None	---	0	0	0
11B	None	---	0	0	0	28C	None	---	0	0	0
13A	None	---	0	0	0	33	None	---	0	1.4	1.4
13C	None	---	0	0	0	36B	None	---	0	0	0
14	None	---	0	0	0	36C	None	---	0	0	0
16A	None	---	0	0	0	36D	None	---	0	0	0
16C	None	---	0	0	0	37	None	---	0	0	0
17	None	---	0	0	0	38	None	---	0	0	0
19	None	---	0	0	0	39	None	---	0	0	0
20	None	---	0	0	0	40	Salvage	5%	0.2	0	0.2
21B	None	---	0	0	0	45A	None	---	0	0	0
21C	None	---	0	0	0	45B	Seed	60%	3.6	0	3.6
22I	None	---	0	0	0	45C	Seed	100%	6.0	0	6.0
22K	CC	5%	0.3	0	0.3	999*	Var.	68%	3.2	0.3	3.5

The level of pre-existing DSD assigned to Unit 999 in Table 24 is based on the weighted average on a per acre basis of predicted pre-existing DSD levels for all subunits in analysis unit 999. As determined by the 2010 soil monitoring data and field reconnaissance, the level of pre-existing DSD is higher in Unit 999 than the overall average for all treatment units. In all instances where past timber harvesting exists, DSD levels based on field monitoring of soil disturbance are well below estimates presented in the FEIS.

Table 24. Prior DSD calculations for all subunits of aggregated Unit 999.

Tmt Unit	Past Harvest		Prior DSD (%)			Tmt. Unit	Past Harvest		Prior DSD (%)		
	Type	Area %	Disp	Conc	Total		Type	Area %	Disp.	Conc.	Total
99a	None	0	0	0	0	99v	CC	50%	3.0	0	3.0
99b	None	0	0	0	0	99w	CC	100%	6.0	0	6.0
99c	CC	100%	6.0	0	6.0	99x	CC	90%	5.4	0.4	5.8
99d	CC	100%	6.0	0	6.0	99y	CC	10%	0.6	1.6	2.2
99e	CC	70%	4.2	0	4.2	99z	Salvage	100%	3.0	1.8	4.8
99f	CC	100%	6.0	0	6.0	99aa	Salvage	100%	3.0	0	3.0
99g	None	0	0	0	0	99bb	None	0	0	0	0
99h	None	0	0	0	0	99cc	None	0	0	0	0
99i	None	0	0	0	0	99dd	Salvage	100%	3.0	0	3.0
99j	CC	70%	4.2	0	4.2	99ee	None	0	0	0	0
99k	None	0	0	0	0	99ff	CC	100%	6.0	0	6.0
99l	Salvage	100%	3.0	0	3.0	99gg	CC	100%	6.0	0	6.0
99m	Select	100%	1.0	0	1.0	99hh	CC	100%	6.0	0	6.0
99n	None	0	0	0	0	99ii	CC	50%	3.0	0	3.0
99o	Select	100%	1.0	0	1.0	99jj	CC	100%	6.0	0	6.0
99p	Select	100%	1.0	0.9	1.9	99kk	CC	100%	6.0	0	6.0
99q	CC	100%	6.0	0.3	6.3	99ll	CC	100%	6.0	0	6.0
99r	CC	100%	6.0	1.0	7.0	99mm	Seed	20%	1.2	0	1.2
99s	None	0	0	1.1	1.1	99nn	CC	15%	0.9	0	0.9
99t	CC	10%	0.6	1.5	2.1	99oo	CC	10%	0.6	0	0.6
99u	CC	100%	6.0	0	6.0	99pp	CC	100%	6.0	0	6.0

Estimates Detrimental Soil Disturbance Resulting from Proposed Treatment

The calculation of predicted levels of detrimental soil disturbance associated with proposed treatments is based on recent soil monitoring of existing DSD levels from past harvest activity, predicted DSD from proposed treatments and expected reductions in DSD from remediation activity. Levels of DSD from past harvest and effectivness of remediation have been discussed already.

Predicted treatment effects are expected increases in activity related DSD resulting from fuel treatments and associated actitivies. Sources of DSD would include fuels treatments where either partial cutting or prescribed burning are used to remove material. Estimates of expected new DSD also take into account the effects of coarse textures and rock fragments on the soils suceptability to DSD, the method of yarding to be used and the amount of temporary road construction attributed to each treatment unit.

Once again data for treatment units in Alternative 6 (Table 25) and the assessment of subunits in the combined Unit 999 (Table 26) would be used to illustrate the approach, used as well as provide detailed results for the proposed alternatives. A summary of results for all action alaternatives is in the *Comparison of Alternatives* section.

Fuel treatments are regarded in the 2009 Region 1 – Approach to Soils NEPA Analysis Regarding Detrimental Soil Disturbance in Forested Areas (USDA-R1, 2009) as "ground based activities with effects appearing to be much lower that 15%". Values used for calculating treatment effects for this Project are noted here. For all tractor units, initial DSD attributed to skid trails would be 5% given the designed skid trail spacing and expectation of 40% DSD resulting from treatment along all skid trails Dispersed DSD off skid trails would be estimated to be 2%. This estimate is based on restricting the use of harvesting and skidding equipment off skid trails to periods when soil moisture conditions are favorable and due to the presence of coarse textured soils.

Helicopter logging is assumed to have little or no DSD directly associated with tree removal but 0.5% DSD would be allocated for disturbances at off site landings. It is difficult to predict the actual number of landings or potential increased disturbance associated with these offsite landings given the flexibilty of helicopter yarding. For that reason, a straight percentage (0.5%) was used.

Skyline methods are assumed to create 1% dispersed detrimental soil disturbance plus allocations for landings and temporary road construction. Landings have been apportioned to treatment units at one half acre landing per 20 acres for all tractor and skyline units with commercial thinning and one third acre landing per 20 acres for precommercial thinning tractor units. Calculations for temporary road construction were described in the Methodology section. Treatment Units of 4 acres or less were assumed to be yarded to landings on adjacent units or along existing roads.

Assumptions used to calculate dispersed detrimental soil disturbance in treatment units are based on fuels treatments (partial cuts) with approximately 30 to 50% canopy cover removal and coarse textured surface soils with limited amounts of rock fragments in upper soil layers. These assumptions are as follows: tractor units 7% DSD based on 5% for skid trails and 2.3% in dispersed DSD between skid trails, skyline units 1% DSD, prescribed burn units 0.5% DSD, and helicopter units with 0% dispersed DSD.

Table 25 distinguishes between dispersed activity related disturbances within treatment units and concentrated disturbances along proposed temporary roads and landings. Thus, separate columns exist for temporary roads and landings.Width of DSD along newly constructed, temporary roads is considered to be 14 feet based on measurements along a number of temporary roads on the Forest during the past year. The area of disturbance is considered to be 100% detrimentally disturbed from the time the road is first constructed.

Table 25. Predicted levels of treatment related detrimental soil disturbance by treatment unit for Alternative 6.

Treatment Unit	Acres	Method	Treatment Detrimental Soil Disturbance					
			Dispersed	Temporary		Landings		Tmt
			%	Length	%	No.	%	%
1A	32	Tractor	7	0	0	2	3.1	10.1
1B	21	Tractor	7	0	0	1	2.4	9.4
3	876	Burn	0.5	0	0	0	0	0.5
7A	21	Heli.	0	0	0	na	0.5	0.5
7B	68	Burn	0.5	0	0	0	0	0.5
7C	48	Burn	0.5	0	0	0	0	0.5
8	79	Burn	0.5	0	0	0	0	0.5
9	51	Heli.	0	0	0	na	0.5	0.5
10	128	Heli.	0	0	0	na	0.5	0.5
11A	105	Heli.	0	0	0	na	0.5	0.5
11B	70	Heli.	0	0	0	na	0.5	0,5
13A	57	Heli.	0	0	0	na	0.5	0.5
13C	148	Tractor	7	6336	1.4	8	2.7	11.1
14	50	Heli.	0	0	0	na	0.5	0.5
16A	149	Tractor	7	5280	1.1	8	2.7	10.8
16C	29	Skyline	1	5280	5.9	2	3.4	10.3
17	79	Heli.	0	0	0	na	0.5	0.5
19	82	Burn	0.5	0	0	0	0.5	0.5
20	23	Tractor	7	5808	8.1	1	2.2	17.3
21B	2	Tractor	7	0	0	0	0.5	7.0
21C	24	Tractor	7	0	0	1	2.1	9.1
22C	63	Burn	0.5	0	0	0	0.5	0.5
22I	120	Skyline	1	1584	0.4	6	2.5	3.9
22K	89	Skyline	1	0	0	5	2.8	3.8
22L	58	Skyline	1	5808	3.2	3	2.6	6.8
22N	20	Tractor	7	0	0	1	2.5	9.5
22O	3	Tractor	7	0	0	0	0	7.0
22P	4	Tractor	7	0	0	0	0	7.0
22Q	13	Tractor	7	0	0	1	3.8	10.8
25	39	Tractor	7	0	0	2	2.6	9.6
25A	101	Burn	0.5	0	0	0	0	0.5
26	103	Tractor	7	0	0	5	2.4	9.4
27A	98	Heli.	0	0	0	na	0.5	0.5
28B	38	Skyline	1	0	0	2	2.6	2.6
28C	40	Heli.	0	0	0	na	0.5	0.5
33	22	Tractor	7	0	0	1	2.3	9.3
36B	74	Heli.	0	0	0	na	0.5	0.5
36C	11	Heli.	0	0	0	na	0.5	0.5
36D	47	Skyline	1	0	0	3	3.2	4.2
37	31	Heli.	0	0	0	na	0.5	0.5
38	104	Skyline	1	3696	1.1	5	2.4	4.5
39	150	Tractor	7	6864	1.5	8	2.7	11.2
40	258	Burn	0.5	0	0	0	0	0.5

Treatment Unit	Acres	Method	Treatment Detrimental Soil Disturbance					
			Dispersed	Temporary		Landings		Tmt
			%	Length	%	No.	%	%
45A	8	Tractor	7	0	0	1	6.3	13.3
45B	12	Skyline	1	1056	2.8	1	4.2	8.0
45C	4	Tractor	7	0	0	0	0	7.0
999 (all)	1,117	Tractor	7	0	0	74	2.2	9.2

One half acre landings are allocated to tractor and skyline units per every 20 acres with 5 to 24 acres having one landing, 25 to 44 acres two landings, etc. Landing size is reduced to one third acre in small diameter thinning units. It is assumed that treatment units smaller in size than 5 acres can be combined up with adjacent units in the layout of landings or logs can be decked along existing or temporary roads. The landing area is assumed to be 100% detrimentally disturbed at the end of logging. Logs from helicopter units are assumed to be decked off the unit in areas of existing disturbance. Furthermore, it is assumed that fuelbreak treatments along ridges which include up to 70% canopy cover removal would not create a significant amount of additional DSD in the units in which they are located.

Unit 20 has the highest predicted level of detrimental soil disturbance (17.3%) based on proposed tractor logging, the relatively small area in this unit, and over one mile of temporary road allocated to the unit. There was no pre-treatment DSD in unit 20. A moderate level of soil mitigation would be required along the temporary road to bring this stand into compliance with Region One's 15% maximum DSD standard.

Analysis of treatment impacts for subunits of 999 are presented in Table 26. All subunits are analyzed as though the timber would be removed using ground based mechanized operations even though some these subunits would likely be hand thinned. No temporary roads are associated with the small diameter thinning treatments and all subunits of 999 would have at least one landing. The predicted treatment impacts for treatment units or subunits in Alternative 6 are all within acceptable levels for the BMW fuels project.

Table 26. Predicted levels of treatment related detrimental soil disturbance by subunit of Unit 999, Alternative 6.

Treatment Unit	Acres	Method	Detrimental Soil Disturbance					
			Dispersed	Temporary Roads		Landings		Total
			%	Length	%	No.	%	%
99a	7.9	Tractor	7	0	0	1	4.2	11.2
99b	37.0	Tractor	7	0	0	2	1.8	8.8
99c	76.6	Tractor	7	0	0	4	1.7	8.7
99d	18.1	Tractor	7	0	0	1	1.8	8.8
99e	15.9	Tractor	7	0	0	1	2.1	9.1
99f	62.7	Tractor	7	0	0	3	1.6	8.6
99g	46.9	Tractor	7	0	0	3	2.1	9.1
99h	11.2	Tractor	7	0	0	1	3.0	10.0

Treatment Unit	Acres	Method	Detrimental Soil Disturbance					
			Dispersed	Temporary Roads		Landings		Total
			%	Length	%	No.	%	%
99i	13.4	Tractor	7	0	0	1	2.5	9.5
99j	9.3	Tractor	7	0	0	1	3.6	10.6
99k	5.8	Tractor	7	0	0	1	5.8	12.8
99l	51.8	Tractor	7	0	0	3	1.9	8.9
99m	13.5	Tractor	7	0	0	1	2.5	9.5
99n	50.2	Tractor	7	0	0	3	2.0	9.0
99o	24.6	Tractor	7	0	0	2	2.7	9.7
99p	65.6	Tractor	7	0	0	4	2.0	9.0
99q	30.3	Tractor	7	0	0	2	2.2	9.2
99r	42.0	Tractor	7	0	0	2	1.6	8.6
99s	9.4	Tractor	7	0	0	1	3.6	10.6
99t	20.6	Tractor	7	0	0	1	1.6	8.6
99u	31.4	Tractor	7	0	0	2	2.1	9.1
99v	11.2	Tractor	7	0	0	1	3.0	10
99w	25.2	Tractor	7	0	0	2	2.7	9.7
99x	24.4	Tractor	7	0	0	2	2.7	9.7
99y	8.9	Tractor	7	0	0	1	3.8	10.8
99z	44.4	Tractor	7	0	0	3	2.3	9.3
99aa	6.5	Tractor	7	0	0	1	5.1	12.1
99bb	5.4	Tractor	7	0	0	1	6.2	13.2
99cc	66.5	Tractor	7	0	0	4	2.0	9.0
99dd	4.9	Tractor	7	0	0	1	6.8	13.8
99ee	6.8	Tractor	7	0	0	1	4.9	11.9
99ff	34.4	Tractor	7	0	0	2	1.9	8.9
99gg	13.0	Tractor	7	0	0	1	2.6	9.6
99hh	7.3	Tractor	7	0	0	1	4.6	11.6
99ii	26.1	Tractor	7	0	0	2	2.6	9.6
99jj	46.8	Tractor	7	0	0	3	2.1	9.1

Treatment Unit	Acres	Method	Detrimental Soil Disturbance					
			Dispersed	Temporary Roads		Landings		Total
			%	Length	%	No.	%	%
99kk	18.9	Tractor	7	0	0	1	1.8	8.8
99ll	20.7	Tractor	7	0	0	1	1.6	8.6
99mm	6.2	Tractor	7	0	0	1	5.4	12.4
99nn	21.5	Tractor	7	0	0	1	1.6	8.6
99oo	21	Tractor	7	0	0	1	1.6	8.6
99pp	52.9	Tractor	7	0	0	3	1.9	8.9

Soil Remediation Final DSD Levels

Soil remediation for the Bozeman Municipal Watershed Fuels project would aim to initially reduce DSD in portions of the area most likely to have long-term impacts from the proposed treatments: temporary roads, landings, and skid trails. The initial target would be to reduce DSD in these areas by 40% within the first two years after harvesting and enhance further natural recovery over time. This would require that a more aggressive approach be taken on the remediation of temporary roads and landings than would be required for skid trails. Remediation should not create any more ground disturbance than is absolutely necessary. While noxious weed control is discussed as a separate section of the FEIS, it must be noted that controlling noxious weeds is always an important component of soil remediation after disturbance.

The level of remediation anticipated for skid trails, temporary roads, and landings by the second year for Alternative 6 is presented in Table 27 for all treatment units, and Table 28 for all subunits of Unit 999. The amount of predicted remediation in DSD by the second year is a reflection (40%) of the initial levels of DSD for each of these categories prior to remediation. The long term goal for skid trails and landings would be a 90 to 100% reduction in DSD after 20 years. This is possible in these areas because the topsoil resource remains more or less intact provided soil erosion is controlled.

The long term goal for temporary roads is a 70 to 80% reduction in detrimental soil disturbance over 20 years. This goal is reduced because topsoil gets bladed off of the road bed during construction of temporary roads. On level to moderately sloping grasslands or in forest meadows, topsoil can be effectively windrowed at the edge of the road and brought back to cover the road at closure. Much of the topsoil would be restored in that case. This process becomes much less effective when attempts are made to conserve topsoil by the same means in forested areas, on steeper slopes, and/or in rocky areas or in soils that contain abundant rock fragments larger than 3 inches in diameter. These factors limit potential remediation effectiveness, unless the subsoil has the same basic physical and chemical (not fertility) properties as the overlying topsoil had and the soil is deep or very deep.

Final DSD Levels

No treatment units in Alternative 6 are predicted to exceed the Region One 15% maximum detrimental soil disturbance standard at the end of this project. See Table 27 and 28. The same can be said for Alternatives 2 though 5. Predicted final DSD levels in treatment units of Alternative 6 range from 0.5% in helicopter harvested areas with no prior timber harvesting activity to a high of 11.2% DSD in unit 20 with a high level of activity related DSD from proposed tractor harvesting and over one mile of temporary road, amortized over a relatively small area. Units 20, 45C, and 999 under this alternative would be targeted for inclusion in post treatment soil monitoring at the end of the project due to predicted, post-treatment, DSD levels of 11.2%, 11.0%, and 9.8% percent DSD, respectively.

A number of subunits of Unit 999 have predicted levels of post-treatment DSD above 10%. The overall final DSD in Unit 999 equals 9.8%. The relatively high estimate of DSD in subunits is due, in part, to the potential that all small diameter thinning units would be thinned with the use of ground based equipment; and the relatively high level of past timber harvesting within this Unit. No subunits of Unit 999 would exceed the 15% DSD standard at the end of this project based on estimated final DSD levels. The range in predicted DSD goes from 6.1% in subunit 99b to 13.8% in subunit 99hh. Subunit 99hh was clearcut and has a high level of predicted treatment related DSD. High treatment estimates are based on disturbance at the landing being amortized over only 7.3 acres.

There are a total of 20 out of 42 subunits that would have expected post-treatment DSD levels above 10.0%. These would be targeted for soil monitoring in the second and fifth year after harvest. The stratified soil sampling strategy used would be similar to that for assessing pre-treatment DSD levels. Individual subunits would be grouped based on similarities in soil/site conditions and expected levels of DSD. Representative subunits would then be selected for the soil monitoring.

Table 27. Expected remediation results and calculation of DSD levels for Treatment units two years after treatment for Alternative 6 of the Bozeman Municipal Watershed Fuels project.

Treatment Unit	Acres	Method	DSD		Remediation			Final DSD
			Prior	Treat-ment	Skid Tr.	Temp Rd.	Landings	
			%	%	%	%	%	%
1A	32	Tractor	0.6	10.1	-2.0	0	-1.2	7.5
1B	21	Tractor	2.7	9.4	-2.0	0	-1.0	9.1
3	876	Burn	0.3	0.5	0 0	0	0	0.8
7A	21	Heli.	0	0.5	0	0	0	0.5
7B	68	Burn	0	0.5	0	0	0	0.5
7C	48	Burn	0	0.5	0	0	0	0.5
8	79	Burn	0	0.5	0	0	0	0.5
9	51	Heli.	0.9	0.5	0	0	0	1.4
10	128	Heli.	0.3	0.5	0	0	0	0.8

Treatment Unit	Acres	Method	DSD		Remediation			Final DSD
			Prior	Treat-ment	Skid Tr.	Temp Rd.	Landings	
			%	%	%	%	%	%
11A	105	Heli.	0	0.5	0	0	0	0.5
11B	70	Heli.	0	0.5	0	0	0	0.5
13A	57	Heli.	0	0.5	0	0	0	0.5
13C	148	Tractor	0	11.1	-2.0	-0.6	-1.1	7.4
14	50	Heli.	0	0.5	0	0	0	0.5
16A	149	Tractor	0	10.8	-2.0	-0.5	-1.1	7.2
16C	29	Skyline	0	10.3	0	-2.4	-1.4	6.5
17	79	Heli.	0	0.5	0	0	0	0.5~~0~~
19	82	Burn	0	0.5	0	0	0	0.5
20	23	Tractor	0	17.3	-2.0	-3.2	-0.9	11.2
21B	2	Tractor	0	7.0	-2.0	0	0	5.0
21C	24	Tractor	0	9.1	-2.0	0	-0.8	6.3
22C	63	Burn	0	0.5	0	0	0	0.5
22I	120	Skyline	0	3.9	0	-0.2	-1.0	2.7
22K	89	Skyline	0.3	3.8	0	0	-1.1	3.0
22L	58	Skyline	0.3	6.8	0	-1.3	-1.0	4.8
22N	20	Tractor	0	9.5	-2.0	0	-1.0	6.5
22O	3	Tractor	0	7.0	-2.0	0	0	5.0
22P	4	Tractor	0	7.0	-2.0	0	0	5.0
22Q	13	Tractor	0	10.8	-2.0	0	-1.5	7.3
25	39	Tractor	0	9.6	-2.0	0	-1.0	6.6
25A	101	Burn	0	0.5	0	0	0	0.5
26	103	Tractor	0.9	9.4	-2.0	0	-1.0	7.3
27A	98	Heli.	0	0.5	0	0	0	0.5
28B	38	Skyline	0	3.6	0	0	-1.0	2.6
28C	40	Heli.	0	0.5	0	0	0	0.5

Treatment Unit	Acres	Method	DSD		Remediation			Final DSD
			Prior	Treat-ment	Skid Tr.	Temp Rd.	Landings	
			%	%	%	%	%	%
33	22	Tractor	1.4	9.3	-2.0	0	-0.9	7.8
36B	74	Heli.	0	0.5	0	0	0	0.5
36C	11	Heli.	0	0.5	0	0	0	0.5
36D	47	Skyline	0	4.2	0	0	-1.3	2.9
37	31	Heli.	0	0.5	0	0	0	0.5
38	104	Skyline	0	4.5	0	-0.4	-1.0	3.1
39	150	Tractor	0	11.2	-2.0	-0.6	-1.1	7.5
40	258	Burn	0.2	0.5	0	0	0	0.7
45A	8	Tractor	0	13.3	-2.0	0	-2.5	8.8
45B	12	Skyline	3.6	8.0	0	-1.1	-1.7	8.8
45C	4	Tractor	6.0	7.0	-2.0	0	0	11.0
999 (all)	1,117	Tractor	3.5	9.2	-2.0	0	-0.9	9.8

Table 28. Expected remediation results and calculation of DSD levels for subunits of Analysis Unit 999 two years after treatment in Alternative 6 of the Bozeman Municipal Watershed Fuels project.

Treatment Unit	Acres	Method	DSD		Remediation			Final DSD
			Prior	Treat-ment	Skid Tr.	Temp Rd.	Land-ings	
			%	%	%	%	%	%
99a	7.9	Tractor	0	11.2	-2.0	0	-1.7	7.5
99b	37.0	Tractor	0	8.8	-2.0	0	-0.7	6.1
99c	76.6	Tractor	6.0	8.7	-2.0	0	-0.7	12.0
99d	18.1	Tractor	6.6	8.8	-2.0	0	-0.7	12.1
99e	15.9	Tractor	4.2	9.1	-2.0	0	-0.8	10.5
99f	62.7	Tractor	6.0	8.6	-2.0	0	-0.6	12.0
99g	46.9	Tractor	0	9.1	-2.0	0	-0.8	6.3
99h	11.2	Tractor	0	10.0	-2.0	0	-1.2	6.8

Treatment Unit	Acres	Method	DSD Prior	DSD Treat-ment	Remediation Skid Tr.	Remediation Temp Rd.	Remediation Land-ings	Final DSD
			%	%	%	%	%	%
99i	13.4	Tractor	0	9.5	-2.0	0	-1.0	6.5
99j	9.3	Tractor	4.2	10.6	-2.0	0	-1.4	11.4
99k	5.8	Tractor	0	12.8	-2.0	0	-2.3	8.5
99l	51.8	Tractor	2.0	8.9	-2.0	0	-0.8	8.1
99m	13.5	Tractor	0.5	9.5	-2.0	0	-1.0	7.0
99n	50.2	Tractor	0	9.0	-2.0	0	-0.8	6.2
99o	24.6	Tractor	1.0	9.7	-2.0	0	-1.1	7.6
99p	65.6	Tractor	1.9	9.0	-2.0	0	-0.8	8.1
99q	30.3	Tractor	6.3	9.2	-2.0	0	-0.9	12.6
99r	42.0	Tractor	7.0	8.6	-2.0	0	-0.6	13.0
99s	9.4	Tractor	1.1	10.6	-2.0	0	-1.4	8.3
99t	20.6	Tractor	2.1	8.6	-2.0	0	-0.6	8.1
99u	31.4	Tractor	6.0	9.1	-2.0	0	-0.8	12.3
99v	11.2	Tractor	3.0	10	-2.0	0	-1.2	9.8
99w	25.2	Tractor	6.0	9.7	-2.0	0	-1.1	12.6
99x	24.4	Tractor	5.8	9.7	-2.0	0	-1.1	12.4
99y	8.9	Tractor	2.2	10.8	-2.0	0	-1.5	9.5
99z	44.4	Tractor	3.8	9.3	-2.0	0	-0.9	10.2
99aa	6.5	Tractor	2.0	12.1	-2.0	0	-2.0	10.1
99bb	5.4	Tractor	0	13.2	-2.0	0	-2.5	8.7
99cc	66.5	Tractor	0	9.0	-2.0	0	-0.8	6.2
99dd	4.9	Tractor	2.0	13.8	-2.0	0	-2.7	11.1
99ee	6.8	Tractor	0	11.9	-2.0	0	-2.0	7.9
99ff	34.4	Tractor	6.0	8.9	-2.0	0	-0.8	12.1
99gg	13.0	Tractor	6.0	9.6	-2.0	0	-1.0	12.6
99hh	7.3	Tractor	6.0	11.6	-2.0	0	-1.8	13.8

Treatment Unit	Acres	Method	DSD		Remediation			Final DSD
			Prior	Treat-ment	Skid Tr.	Temp Rd.	Land-ings	
			%	%	%	%	%	%
99ii	26.1	Tractor	3.0	9.6	-2.0	0	-1.0	9.6
99jj	46.8	Tractor	6.0	9.1	-2.0	0	-0.8	12.3
99kk	18.9	Tractor	6.0	8.8	-2.0	0	-0.7	12.1
99ll	20.7	Tractor	6.0	8.6	-2.0	0	-0.6	12.0
99mm	6.2	Tractor	0.8	12.4	-2.0	0	-2.2	9.0
99nn	21.5	Tractor	0.9	8.6	-2.0	0	-0.6	6.9
99oo	21	Tractor	0.6	8.6	-2.0	0	-0.6	6.6
99pp	52.9	Tractor	6.0	8.9	-2.0	0	-0.8	12.1

Other Potential Concerns

Temporary roads if poorly sited have the potential to increase inherent landslide hazards on steep mountains slopes. Ratings in the Soil Survey (USDA-NRCS 1996) for risk of landslide indicate low to moderate landslide potential along proposed temporary road routes. These risk ratings appear reasonable provided adequate attention is paid to siting final road locations. Sedimentary parent materials in treatment units 16A, 16C, and 39 west of Hyalite Creek and steep north facing mountain slopes with seeped areas would require the most diligence for siting temporary roads.

Comparisons Among Alternatives

Alternatives in the Bozeman Municipal Watershed Fuels Project cover a range of different fuel reduction options along with a No Action Alternative (Alternative 1). Differences among the fuel reduction options relate mainly to how wood products and/or woody debris are removed from the forest and the amount of forest land treated. Alternative 2 was the original fuel reduction proposal. It represents a more modest approach to fuels reduction than some of the other alternatives. Alternative 3 emphasizes the use of skyline methods to remove wood from forest stands. This alternative reduces the level of soil disturbance from tractor harvesting but requires more temporary roads to be built. Alternative 3 has more total acreage in treatment units than any of the other alternatives.

Alternative 4 utilizes prescribed burning as the primary means of fuels reduction. It still includes, however, a fair amount of tractor harvesting in small diameter stands within core areas of the Bozeman Municipal Watershed. Alternative 5 emphasizes the use of helicopters to yard logs. It contains almost as much acreage in treatment units as Alternative 3. Alternative 6 is the preferred alternative, a somewhat scaled back alternative from Alternatives 3 and 5 that utilizes more of a mixture of tractor, skyline, helicopter, and broadcast burning to reduce fuel loads.

Detrimental soil disturbance for all of the fuel reduction alternatives is estimated to remain below the Region One maximum detrimental soil disturbance standard of 15% DSD at the end of the project. In addition, all treatment sub-units in the area with the highest amount of past harvesting (Analysis unit 999 for Alternative 6 or Units 32 and 33 for Alternatives 2, 3, 4, and 5) would meet the Regional standard as well. Table 29 provides a quick summary of differences among the various alternatives:

In general, comparisons of detrimental soil disturbance among alternatives can be made from the type of harvest method emphasized. Helicopter and prescribed burning create the least amount of DSD while timber harvesting with tractors creates the most. Skyline yarding creates much less dispersed DSD than tractor yarding but often requires more temporary roads to be built. The fuels treatments in the alternatives include the same small tree thinning in core areas of the BMW. This is the area with the highest level of past harvest impacts and represents a realtively large proportion of the total area proposed for treatment. This common feature in all of the action alternatives tends to mask differences among alternatives.

Beyond the Regional DSD standard, other metrics have been used to compare relative levels of DSD among Alternatives. All Alternatives cover roughly the same area and core area. Thus, levels of past harvest disturbance are quite similar for all Alternatives. Proposed tractor harvested acres or percent of total acres and miles of temporary road are two effective measures of potential post-treatment DSD, especially if they are used together. Other metrics used are the total area treatments, number of acres or proportion of area with less than 1% DSD, and number of acres or proportion of area with greater than 6% DSD. Results from the above are presented in Table 29.

Table 29. Comparisons of detrimental soil disturbance among Alternatives.

Alt. No.	Total Acres	Temp. Road	Tractor Units		Treatment Units < 1% DSD		Treatment Units ≥ 6% DSD	
		mi.	Acres	%	Acres	%	Acres	%
1	0	0	0	na	na	75.2†	0	0
2	3926	7.2	1587	40.4	1421	36.2	1325	33.7
3	5871	13.5	1840	31.3	1858	31.6	1444	24.6
4	4985	0	1231	24.7	3107	62.3	1231	24.7
5	5814	6.9	2010	34.6	2009	34.6	1478	25.4
6	4737	7.1	1860	39.3	2279	48.1	1185	40.4

† *Based on treatment units in Alternative 6.*

Alternative 1

The No Action Alternative (Alternative 1) would have no timber harvesting disturbance. Existing levels of DSD associated with past harvests would not increase but would persist. Organic substrates would continue to accumulate in stands with increases in litter layer thickness, higher amounts of coarse woody debris, and increased soil organic matter levels in upper mineral soil layers. Eventually, these levels would be reduced by wildfires. The possibility exists that the organic substrates levels, including litter layer thickness would exceed optimum levels for lodgepole pine and possibly other species on some sites. The no action alternative likely has the highest probability for detrimental soil disturbance from severe burning due to the continued build-up of woody fuels resulting in an increased threat of severe wildfire activity.

Alternative 2 – Proposed Action

Treatment units in this alternative would cover a relatively small number of acres compared to some of the other alternatives. It would have one of the highest percentages of tractor logging (40.4%) of the alternatives analyzed, but the second smallest total acres of tractor logging. The total length of proposed temporary road construction, 7.2 miles, is comparable to other fuel reduction alternatives in the mid-range for amount of road to be built. It would have the second highest mile (temp road)/100 acre ratio, 0.183 mi./100 ac., of the alternatives considered in this analysis.

As with nearly all the alternatives, the small diameter stand thinning Units 32 and 33 would have the highest level of predicted, post-activity DSD at 9.4% and 11.3%, respectively. Only one other treatment unit in this Alternative, Unit 16 with 6.8% , would exceed a DSD level of 6.0%. Potential impacts from Alternative 2 would fall well within the Regional DSD standard for all treatment units. No treatment units in Alternative 2 would be expected to exceed the Region One 15% allowable DSD standard.

Alternative 3 – Increaed treatments to increase overall effectiveness toward meeting the purpose and need.

Alternative 3 would include fuels treatments covering a much larger acreage than Alternative 2. Total combined area of proposed treatment units equal 5,871 acres. This alternative would have a similar mix of harvest method alternatives as Alternative 2 but would have less ground based harvesting (31.3% of acres) in favor of helicopter and skyline systems. The total acres of ground based harvest in this alternative would be one of the highest because of the total area/acres being treated in this alternative.

The trade off in DSD for this alternative would be increased temporary road construction (13.5 mi.) versus fewer tractor harvest units. Although detrimental soil disturbances along skid trails and temporary roads would be counted equally towards the 15% standard, long term reductions in soil productivity, as well as soil quality, would be more likely with temporary roads. This alternative would have the highest ratio of temporary road construction/100 acres for any of the proposed alternatives at 0.230 mi./100 ac. Detrimental soil disturbance levels would be highest in Treatment Units 32 and 33 with the same levels, 9.4% and 11.3%, as Alternative 2. As compared to Alternative 2, two other treatment units, Unit 16 and Unit 26, would have DSD levels estimated at or above 6.0%. No treatment units in Alternative 3 would be expected to exceed the Region One 15% allowable DSD standard.

Alternative 4 – Broadcast burn and small tree thinning Alternative

Alternative 4 would emphasize broadcast burning almost exclusively over commercial timber harvesting. The only exception being some commercial products that may be present in small diameter stands slated for pre-commercial thinning. Use of ground based equipment would remain an option for thinning and possible commercial use of material from 1,231 acres of small diameter stands. This alternative is intermediate in terms of total acres treated. No new construction of temporary roads would be required with this alternative.

Once again, Treatment Units 32 and 33 would have the highest predicted levels of DSD with 9.4% and 11.3% DSD, respectively. Only one additional unit is predicted to have over 6.0% detrimental soil disturbance. None of the other treatment units would come close to that level. No treatment units in Alternative 4 would be expected to exceed the Region One 15% allowable DSD standard.

Alternative 5 – Scenery, Fisheries and Water Quality Mitigation

This alternative would treat nearly as large an area, 5,814 acres, as Alternative 3. To accomplish this and minimize post-treatment DSD levels, helicopter yarding is proposed on nearly 43% of the area to be treated. Alternative 5 would retain the largest total area of ground based harvest, 1,930 acres, of any alternative. The level of detrimental soil disturbance from ground based logging would be spread over a large amount of total acres in this Alternative. Temporary road construction of 6.9 miles in this Alternative would be comparable to other Alternatives in the middle range for temporary road construction in this project. The ratio of temporary road construction per 100 acres in this treatment is 0.119 mi./100 ac. which aside from the controlled burn alternative (Alt. 4) is the lowest level among all the fuel reduction options.

Once again, Treatment Units 32 and 33 would have the highest levels of DSD in this alternative, with 9.4% and 11.3%, respectively. Four additional treatment units would have DSD levels equal to or exceeding 6%. Those treatment units are: Unit 5, 25, 26 and 39. Use of helicopter harvesting would create mimimal levels of detrimental soil disturbance. No treatment units in Alternative 5 would be expected to exceed the Region One 15% allowable DSD standard.

Alternative 6 – Preferred Alternative which balances economic realities of helicopter logging costs

This alternative reduces fuels on an intermediate number of acres relative to the other fuel reduction alternatives. It would be scaled down from Alternatives 3 and 5. A mix of treatment and yarding options in Alternative 6 would utilize helicopter logging but the level of use would be reduced to 17% of total acres treated compared to nearly 43% helicopter logging in Alternative 5. Alternative 6 is more similar to Alternative 2 as both alternatives emphasize timber harvesting using ground based equipment and have the highest proportion of ground based (tractor) logging; 40.4% for Alternative 2 and 39.3% in Alternative 6. A total of 7.9 miles of new temporary road construction is planned for this alternative.

Treatment Units 32 and 33 were combined to a single 999 unit in the Soils analysis for Alternative 6. Units 32 and 33 are both within in the core area of the BMW that was heavily havested 30 to 60 years ago. Planned treatments for both units would be the same, pre-commercial thinning in small diameter stands with some potential mechanized harvesting. This made combining the two units for analysis a reasonable approach. The analysis for Unit 999 in Alternative 6 was then based on subunits to allow for more precise analysis that correspond with past harvest locations and cutting boundaries.

The combined Treatment Unit 999 has an overall predicted level of post-activity DSD of 9.8% based on much more detailed analysis of selected subunits as discussed previously. The range in predicted levels of post-activity DSD for individual subunits of Unit 999 (Table 28) was 6.1% to 13.8%. No subunits exceeded the 15% DSD limit. The overall highest levels of predicted, post-activity DSD among treament units in Alternative 6 were 11.0% DSD in the small, 4 acre, Treatment Unit 45C and 11.2% DSD in the 23 acre Treatment Unit 20. In addition to Units 999, 45C and 20 noted above, there were 14 additional treatment units in Alternative 6 predicted to have post-harvest DSD levels above 6.0%

Overall levels of detrimental soil disturbance within treatment units in Alternative 6 would be higher than for the other alternatives analyzed. This is evident by the number of treatment units with predicted, post-activity, DSD levels exceeding 6.0% and the percentage of treated acres that are predicted to exceed 6.0% DSD. Regardless of the increased levels, there are no treatment units in Alternative 6 or subunits of Unit 999 that would be expected to exceed the Region One 15% maximum allowable DSD standard.

<u>Summary of Comparisons</u>

The proportion of acres that would have less than 1% DSD identifies how much of the acreage in Treatment Units would have very little post-treatment DSD. Alternative 6, is predicted to have the highest proportion of area with little or no DSD, just above Alternative 4. Previously harvested, ground based units in core areas of the BMW are spread over a larger area in Alternative 6 relative to Alternative 4. The other three alternatives (2, 3, and 5) would have roughly the same proportion of area predicted to have little or no post-treatment DSD.

Treatment Units with final predicted levels of DSD above 8.0 would be targeted for post-treatment soil monitoring. This level is well below the 15% Region One standard but high enough to warrant closer attention by monitoring at 2 years and again at year 5 after fuel treatment and remediation are complete.

Of the six Alternatives, Alternative 4, with emphasis on broadcast burning has the highest proportion of area predicted to have over 8% DSD. This is solely due to the fact that Alternative 4 has the smallest total acreage over which the areas with >8% DSD can be spread or amoritized.

Overall, differences would be small in predicted, post-treatment DSD levels among the alternatives. They reflect differences in the total acreage treated for these alternatives and the fact that all of the action alternatives have essentially the same approach to treating previously harvested, small diameter stands in core areas of the BMW project. The only real significant difference among the action alternatives from a soils perspective is that Alternative 3, which emphasizes skyline yarding, has 13.5 miles of temporary road construction planned (FEIS, p. 2-26), nearly twice the level proposed for Alternatives 2, 5, and 6. Alternative 4 which focuses on prescribed burning includes no temporary road construction.

Alternative 1, the no action alternative, has the least amount of activity related DSD of all alternatives considered. The trade off is that Alternative 1 would pose the greatest potential threat to long term soil productivity and the integrity of Bozeman's Municipal

Watershed if a severe wildfire were to burn through the area. Tables summarizing DSD levels by treatment unit for each Alternative are presented below in Tables 30-34.

Table 30. Summary table of detrimental soil disturbance calculations for Alternative 2.

Activity Area	Current DSD(%)	Potential DSD(%)			Cum. DSD w/o Mitigation	Reduced DSD from Mitigation	Total Post Activity DSD
		Activity	Temp. Roads	Landings			
1	0	0	0	0.5	0.5	0	0.5
3	0.3	0.5	0	0	0.8	0	0.8
4	0.5	0	0	0.5	1.0	0	1.0
7	0	0	0	0.5	0.5	0	0.5
8	0	0	0	0.5	0.5	0	0.5
9	0.9	0	0	0.5	1.4	0	1.4
10	0.3	0	0	0.5	0.8	0	0.8
11	0	0	0	0.5	0.5	0	0.5
12	0	1.8	0.8	2.4	5.0	-1.6	3.4
13	0	3.0	1.1	2.3	6.4	-2.1	4.3
16	0	5.2	2.4	2.6	10.2	-3.4	6.8
17	0	0	0	0	0	0	0
22	0.2	2	1.0	2.4	5.6	-1.5	4.1
24	0	0.5	0	0.5	1.0	0	1.0
26	0.3	5.7	0	2.5	8.5	-2.6	5.9
28	0	0.6	0	2.5	3.1	-0.8	2.3
29	0.2	2.2	0	2.6	5.0	-1.4	3.6
31	1.8	0.4	0	1.0	3.2	-0.4	2.8
32	3.4	7	0	1.7	12.1	-2.7	9.4
33	5.3	7	0	1.7	14.0	-2.7	11.3

Table 31. Summary table of detrimental soil disturbance calculations for Alternative 3.

Activity Area	Current DSD(%)	Potential DSD(%) Activity	Potential DSD(%) Temp. Roads	Potential DSD(%) Landings	Cum. DSD w/o Mitigation	Reduced DSD from Mitigation	Total Post Activity DSD
1	0	0	0	0.5	0.5	0	0.5
2	0	0	0	0.5	0.5	0	0.5
3	0.3	0.5	0	0	0.8	0	0.8
4	0.5	0	0	0.5	1.0	0	1.0
5	0	0	0	0.5	0.5	0	0.5
7	0	0	0	0.5	0.5	0	0.5
8	0	0	0	0.5	0.5	0	0.5
9	0.9	0	0	0.5	1.4	0	1.4
10	0.3	0	0	0.5	0.8	0	0.8
11	0	0	0	0.5	0.5	0	0.5
12	0	1.8	0.6	2.4	4.8	-1.5	3.3
13	0	3.4	0.9	2.5	6.8	-2.2	4.6
14	0	3.7	2.3	2.8	8.8	-2.9	5.9
15	0	2.8	1.5	2.3	6.6	-2.0	4.6
16	0	5.2	1.8	2.6	9.6	-3.2	6.5
18	0	0.4	1.6	1.9	3.9	-1.2	2.7
19	0.2	2.2	0.8	2.3	5.5	-1.5	4.0
20	0	1.3	1.8	2.4	5.5	-1.7	3.8
21	0.3	2.6	0.5	1.7	5.1	-1.4	3.7
22	0.5	2.0	0.3	2.4	5.2	-1.3	3.9
24	0	0.5	0	0	0.5	0	0.5
25	0.9	0.5	0	0	1.4	0	1.4
26	0.3	5.8	0	2.5	8.6	-2.6	6.0
27	0	1.0	0.7	2.6	4.3	-1.3	3.0
28	0	1.0	1.1	2.6	4.7	-1.5	3.2
29	0.2	2.2	0	2.4	4.8	-1.4	3.4
30	3	1.0	0	2.4	6.4	-1.0	5.4
31	1.8	0.4	0	1.5	3.7	-0.4	3.3
32	3.4	7.0	0	1.7	12.1	-2.7	9.4
33	5.3	7.0	0	1.7	14.0	-2.7	11.3

Table 32. Summary table of detrimental soil disturbance calculations for Alternative 4.

Activity Area	Current DSD(%)	Potential DSD(%) Activity	Potential DSD(%) Temp. Roads	Potential DSD(%) Landings	Cum. DSD w/o Mitigation	Reduced DSD from Mitigation	Total Post Activity DSD
1	0	0.5	0	0	0.5	0	0.5
3	0.3	0.5	0	0	0.8	0	0.8
4	0.5	0.5	0	0	1.0	0	1.0
7	0	0.5	0	0	0.5	0	0.5
8	0	0.5	0	0	0.5	0	0.5
10	0	0.5	0	0	0.5	0	0.5
11	0	0.5	0	0	0.5	0	0.5
12	0	0.5	0	0	0.5	0	0.5
13	0	0.5	0	0	0.5	0	0.5
15	0	0.5	0	0	0.5	0	0.5
16	0	0.5	0	0	0.5	0	0.5
17	0	0.5	0	0	0.5	0	0.5
18	0	0.5	0	0	0.5	0	0.5
19	0.2	0.5	0	0	0.7	0	0.7
21	0	0.5	0	0	0.5	0	0.5
22	0.5	0.5	0	0	1.0	0	1.0
23	0.6	0.5	0	0	1.1	0	1.1
24	0	0.5	0	0	0.5	0	0.5
25	0	0.5	0	0	0.5	0	0.5
26	0.3	7.0	0	1.8	9.1	-2.7	6.4
28	0	0.5	0	0	0.5	0	0.5
29	0	0.5	0	0	0.5	0	0.5
32	3.4	7.0	0	1.7	12.1	-2.7	9.4
33	5.3	7.0	0	1.7	14.0	-2.7	11.3
34	0	0.5	0	0	0.5	0	0.5
35	0	0.5	0	0	0.5	0	0.5
36	0	0.5	0	0	0.5	0	0.5

Table 33. Summary table of detrimental soil disturbance calculations for Alternative 5.

Activity Area	Current DSD(%)	Potential DSD(%)			Cum. DSD w/o Mitigation	Reduced DSD from Mitigation	Total Post Activity DSD
		Activity	Temp. Roads	Landings			
1	0	0	0	0.5	0.5	0	0.5
2	0	0	0	0.5	0.5	0	0.5
3	0.3	0.5	0	0	0.8	0	0.8
4	0.5	0	0	0.5	1.0	0	1.0
5	0	7	0	1.7	8.7	2.7	6.0
6	0	0	0	0	0	0	0
7	0	0	0	0.5	0.5	0	0.5
8	0	0	0	0.5	0.5	0	0.5
9	0.9	0	0	0.5	1.4	0	1.4
10	0.3	0	0	0.5	0.8	0	0.8
11	0	0	0	0.5	0.5	0	0.5
12	0	0	0	0.5	0.5	0	0.5
13	0	2.5	0.6	1.9	5.0	1.4	3.6
14	0	2.2	1.6	1.4	5.2	1.6	3.6
15	0	1.3	0	1.0	2.3	0.6	1.8
16	0	5.3	0	2.6	7.9	2.5	5.4
17	0	0.3	0	1.7	2.0	0.5	1.5
18	0	0.2	4.4	1.5	6.0	2.1	3.9
20	0	0.4	0.9	1.6	2.9	0.8	2.1
21	0.3	2.7	0.8	1.6	5.4	1.5	3.9
22	0.5	1.1	0	1.5	3.1	0.6	2.5
25	0	7.0	0	2.6	9.6	3.0	6.6
26	0.3	7.0	0	2.6	9.9	3.0	6.9
27	0	0	0	0.5	0.5	0	0.5
28	0	0.5	0	1.8	2.3	0.5	1.8
29	0.2	1.3	0	1.2	2.7	0.7	2.0
30	3.0	0	0	0.5	3.5	0	3.5
32	3.4	7.0	0	1.7	12.1	2.7	9.4
33	5.3	7.0	0	1.7	14.0	2.7	11.3
36	0	0	0	0.5	0.5	0	0.5
37	0	0	0	0.5	0.5	0	0.5
38	0	0	0	0.5	0.5	0	0.5
39	0	7.0	0.2	2.6	9.8	3.1	6.7
40	0	0.5	0	0	0.5	0	0.5

Table 34. Summary table of detrimental soil disturbance calculations for Alternative 6.

Activity Area	Current DSD(%)	Potential DSD(%)			Cum. DSD w/o Mitigation	Reduced DSD from Mitigation	Total Post Activity DSD
		Activity	Temp. Roads	Landings			
1A	0.6	7	0	3.1	10.7	-3.2	7.5
1B	2.7	7	0	2.4	12.1	-3.0	9.1
3	0.3	0.5	0	0	0.8	0	0.8
7A	0	0	0	0.5	0.5	0	0.5
7B	0	0.5	0	0	0.5	0	0.5
7C	0	0.5	0	0	0.5	0	0.5
8	0	0.5	0	0	0.5	0	0.5
9	0.9	0	0	0.5	1.4	0	1.4
10	0.3	0	0	0.5	0.8	0	0.8
11A	0	0	0	0.5	0.5	0	0.5
11B	0	0	0	0.5	0.5	0	0.5
13A	0	0	0	0.5	0.5	0	0.5
13C	0	7	1.4	2.7	11.1	-3.7	7.4
14	0	0	0	0.5	0.5	0	0.5
16A	0	7	1.1	2.7	10.8	-3.6	7.2
16C	0	1	5.9	3.4	10.3	-3.8	6.5
17	0	0	0	0.5	0.5	0	0.5
19	0	0.5	0	0	0.5	0	0.5
20	0	7	8.1	2.2	17.3	-6.1	11.2
21B	0	7	0	0	7.0	-2.0	5.0
21C	0	7	0	2.1	9.1	-2.8	6.3
22C	0	0.5	0	0	0.5	0	0.5
22I	0	1	0.4	2.5	3.9	-1.2	2.7
22K	0.3	1	0	2.8	4.1	-1.1	3.0
22L	0.3	1	3.2	2.6	7.1	-2.3	4.8
22N	0	7	0	2.5	9.5	-3.0	6.5
22O	0	7	0	0	7.0	-2.0	5.0
22P	0	7	0	0	7.0	-2.0	5.0
22Q	0	7	0	3.8	10.8	-3.5	7.3
25	0	7	0	2.6	9.6	-3.0	6.6
25A	0	0.5	0	0	0.5	0	0.5
26	0.9	7	0	2.4	10.3	-3.0	7.3
27A	0	0	0	0.5	0.5	0	0.5
28B	0	1	0	2.6	3.6	-1.0	2.6
28C	0	0	0	0.5	0.5	0	0.5
33	1.4	7	0	2.3	10.7	-2.9	7.8

Activity Area	Current DSD(%)	Potential DSD(%)			Cum. DSD w/o Mitigation	Reduced DSD from Mitigation	Total Post Activity
36B	0	0	0	0.5	0.5	0	0.5
36C	0	0	0	0.5	0.5	0	0.5
36D	0	1	0	3.2	4.2	-1.3	2.9
37	0	0	0	0.5	0.5	0	0.5
38	0	1	1.1	2.4	4.5	-1.4	3.1
39	0	7	1.5	2.7	11.2	-3.7	7.5
40	0.2	0.5	0	0	0.7	0	0.7
45A	0	7	0	6.3	13.3	-4.5	8.8
45B	3.6	1	2.8	4.2	11.6	-2.8	8.8
45C	6.0	7	0	0	13.0	-2.0	11.0
999 (all)	3.5	7	0	2.2	12.7	-2.9	9.8

Cumulative Effects (All Action Alternatives)

Soil productivity effects are spatially static in that productivity at one location does not influence productivity in another location (USFS 2009) provided off site impacts from soil erosion, deposition, and mass wasting do not occur. From a soil productivity standpoint, it can be appropriate to spatially limit the cumulative effects analysis to the activity area.

The metric used in Region 1 to determine whether soil productivity has been reduced is the occurrence of detrimental soil disturbance and the 15% maximum allowable standard. DSD, as well as soil productivity, is not a scale dependent variable and can be used to describe conditions at a site, in a field or treatment unit, on a hillside or for an entire drainage basin. At times it may be appropriate in application of the DSD standard to include areas of Forest Service lands adjacent to treatment units when assessing cumulative effects on soils. This approach would be used if there is some reasonable expectation that past or future activity related disturbances outside treatment boundaries may exceed levels inside treatment boundaries.

An appropriate spatial boundary for soil disturbance cumulative effects in the Bozeman Municipal Watershed is a continuous area that includes all treatment units identified in the project as well as the interconnecting National Forest lands between treatment units, and any adjacent Forest Service lands that could potentially affect DSD levels due to soil erosion, deposition, or mass wasting. This does not mean that soil monitoring needs to be conducted outside treatment unit boundaries but does infer a need to look outside treatment boundaries to interconnecting areas when assessing cumulative effects. The area above is the cumulative effects analysis boundary. Lands outside this area would not have cumulative effects with the BMW project because they are spatially separate from lands within BMW treatment units. For the purposes of this analysis, the cumulative effects spatial analysis boundary includes all treatment units and interconnecting lands between treatment units, plus all landings or temporary roads outside treatment units.

Potential Cumulative Impacts of Concern

Illegal off road 4WD travel in precommercial thin (PCT) units could be increased if timber harvesting in conjunction with personal use firewood cutting creates alleyways or entry points heading into forest stands. The treatment units of some concern are Units 32 and 33 in Alternatives 2, 3, 4, 5 and Unit 999 in Alternative 6. These Units contain the majority of easily accessed lands along system roads that do not have topographic constraints to off-road 4 wheel drive (4WD) use. Disturbance associated with ORV/4WD, make-shift shooting ranges, and personal use firewood cutting could progressively migrate further into forest stands if as access increases.

These issues are primarily an administrative enforcement issue. Implementation of the proposed fuels treatments are not expected to increase the potential for additional illegal 4WD use. Leaving behind the required amount of coarse woody fuels, 10 to 15 tons per acre, will be the most efficient means of addressing these concerns. Logs left behind should be scattered in random fashion. This would reduce the possibility that proposed treatments would increase illegal degradation of forest lands. Routine patrols by Forest Service employees are intended to identify this sort of resource conflict if it were to occur. Regulation of firewood cutting in the area is an administrative option that is available if this activity becomes a problem.

The interaction between noxious weed species and soil disturbance is a second topic of concern relative to cumulative effects on soil resources from the treatments. Although the level of activity related DSD for all alternatives is well within Region One standards, there would be some disturbance caused by the proposed fuels treatments. Increased soil disturbance could open additional areas to weed infestation. Weed infestations, in turn, often reduce the effectiveness of vegetative protection, potentially contributing to increased detrimental soil erosion.

Dispersed disturbances between skid trails in tractor units are not continuous and so do not generally represent vectors for weed migration. Temporary roads, skid trails, and landings, however, are potential pathways for spreading weeds. Standard contract provisions include cleaning and removal of any weed seed from all wheeled or tracked harvesting equipment prior to entry onto Forest Lands. In addition, areas infested with noxious weeds would be avoided (not mechanically harvested) in areas where activities could spread weed seeds (FEIS p. 2-17).

Remediation actions for Bozeman Municipal Watershed Fuels Reduction focus on treating temporary roads, landings and disturbed portions of skid trails. Seeding would always accompany any remediation disturbance actions in these areas. In areas where the threat of noxious weed spread is low, attempts would be made to establish diverse native vegetation similar to pre-disturbance conditions. Seeding areas of concern near noxious weed populations would focus much more aggressively on rapid establishment of native vegetation that can effectively exclude weed species. Mitigation included in the alternative would greatly reduce the number of weeds likely to become established in an area. Follow-up weed treatments, if needed, would be conducted by Forest Service personnel.

Cumulative Effects – No Action Alternative

Cumulative effects of the No Action Alternative would likely include the continued accumulation of additional fuel loads in forest stands. This would not be a concern in wet years. During extremely dry years, the increase in fuel loads adds to the potential for a major wildfire. Fire would likely occur at a time when fuel and weather conditions are at their worst in terms of difficulty for fire fighters to control the blaze and for the likelihood of severe burning of forest soils. Weed infestations would have likely continued to build up slowly during intervening years.

Although uncertainty exists, the most likely scenario for the No Action Alternative is that it would pose the greatest hazard for long term detrimental soil disturbance among all alternatives due to severe burning of the forest floor and resulting soil erosion. The level of DSD created would in turn reduce soil productivity over large areas and create bare ground, ripe for the spread of noxious weeds. Initial estimates from BAER analysis of the 2006 Derby Fire south of Big Timber indicated 61.8% of forested areas within the fire perimeter were severely burned, i.e. detrimentally disturbed, and 19.7% were moderately burned (USFS-NRCS 2006). Later monitoring showed less severe burning, so the the estimates were reduced to 7.4% severely burned and 50.6% moderately burned.

Recent personal observations of fire impacts from the Derby Fire by the current Soil Scientist of the Gallatin National Forest (Tom Keck) verify that a substantial amount of the charred, previously forested areas, were severely burned and extensive soil erosion occurred in very channery, coarse textured soils. This same scenario could just as easily occur in the Bozeman Municipal Watershed if extreme drought conditions return.

Soil Mitigation – Included in action alternatives

Skidding and Harvesting Equipment Limitations

Ground based skidding equipment may only travel off of the established skid trails to the extent reasonably necessary for harvesting the available timber based on the sale administrator's judgment and only when the top 6 inches of soil will not form a ball when squeezed in the palm of the hand that will withstand a moderate amount of handling. (Criteria integrates the combined influence of soil texture and soil moisture – *see USDA Technical Guide for Estimating Soil Moisture* (USDA-NRCS 1998).

Feller/buncher/mechanical harvesters may only be used off established skid trails to the extent reasonably necessary to harvest timber and only when the top six inches of soil will not readily form a ribbon between the thumb and forefinger. (USDA-NRCS 1998) Repeat passes over the same ground should be minimized.

Winter Harvesting Restrictions – Not applicable

Winter harvesting is not planned for this project but is permissable. The guidance in the Forest Wide Best Management Practices would be applied if winter logging is implemented.

Temporary Roads, Landings, and Skid Trails

Landings --- The landings will be ripped to a depth of 6 to 8 inches subject to the following limitations: 1) ripping of landings with burn piles will be completed from the edge of the burn pile to the outermost edge of the landing and 2) ripping may be waived on some sites where soils have abundant large rock fragments (25 percent or more 3 inch or larger) or more than 40 percent rock fragments overall in the top 6 inches of soil. Cut and fill slopes, if present at the margins of landings, may be recommended to be re-contoured based on site conditions, in a manner similar to temporary roads. Ripped areas will be seeded with the appropriate seed mix provided by the Gallatin National Forest. Forest Service personnel will complete slashing of landings after burning is complete.

Temporary Roads --- Cut and fill slopes, where present, may be re-contoured based on site specific conditions. It is not anticipated that very much re-contouring would be required. The road prism will be ripped to a depth of 6 to 8 inches into mineral soil along the entire road length. This requirement may be waived on soils having abundant large rock fragments (25 percent or more 3 inch or larger) or more than 50 percent rock fragments overall in the top 6 inches of soil. Ripped areas will be seeded with the appropriate seed mix provided by the Gallatin National Forest. The composition or mix is provided, not necessarily the seed.

Skid Trails --- Ripping skid trails will be required only where detrimentally compacted mineral soil is exposed at the surface or where wheel ruts have formed at least 2 inches deep on grades of 15% or more or continuous to grades of 15% or more. After ripping, these areas will be seeded with the appropriate seed mix, the composition will be provided by the Gallatin National Forest. Skid trails will be slashed at the end of harvesting at a rate of 10 to 15 tons/acre and adequate erosion control measures installed on any slopes steeper than 15%. In addition, provisions to ensure adequate drainage along less steeply sloping grades will be required.

Slash and Coarse Woody Debris

Leave approximately 10 to 12 tons per acre[4] (where available) of existing, coarse woody debris (3" inch or larger) scattered on the ground in treatment units. Coarse woody debris protect the soil surface, slow surface runoff, and return nutrients to the soil.

Slash all temporary roads at an approximate rate of 10 to 15 tons per acre at the completion of logging. Slash left should be oriented primarily at right angles to the road.

Slash skid trails at an approximate rate of 10 to15 tons per acre at the completion of logging. Slash left should be oriented primarily a right angles to the skid trail.

To the extent reasonable, leave sufficient unmerchantable material standing adjacent to landings during harvest so it can be used for slashing landings by the Forest Service at the end of the project. Burn piles should be constructed more like mounds than steep sided dozer piles to facilitate removal of some smaller material by Forest Service personnel prior to burning the pile. This material will used by the Forest Service to slash the area beneath the burn pile after burning is complete.

[4] Coarse woody debris rate from Graham et al. (1994) adjusted for partial cutting in fuels treatments.

Design Criteria

Require a systematic skid trail pattern during logging.

Use ground-based harvest systems only on slopes having sustained grades less than 35 percent.

Maintain an average of at least 75 feet between skid trails in all tractor harvested partial cutting units. Skid trails may be closer than this spacing where converging so long as the overall spacing averages 75 feet or more.

Lay out skid trails in a manner that minimizes, or eliminates where possible, sustained grades steeper than 15%.

Avoid where possible placing skid trails or temporary roads over convex knobs or along narrow, rocky ridges (areas least able to recover from disturbance).

Minimize the depth of blading in construction of temporary roads within the constraints of Forest standards for temporary road construction.

Re-use existing temporary roads, landings, and skid trails in previously harvested areas to the extent practical.

Consistency with Laws, Regulations and Forest Plan Direction.

All soil mitigations and design criteria are intended to keep detrimental soil disturbance in treatment units below the 15% maximum allowable DSD as mandated by the R-1 Supplement 2500-99-1 to FSM 2500 – Watershed and Air Management standards. Coarse woody debris criteria have an additional benefit of ensuring that sufficient organic matter is retained on treatment sites to maintain soil fertility and carbon cycling levels. Other criteria that prevent soil erosion maintain soil fertility and carbon cycling functions in the soil as well.

All of the previously listed soil mitigations and design features for the Bozeman Municipal Watershed Fuels Treatments meet the full intent of laws and directives for the U. S. Forest Service to protect soil and land productivity and soil health without unduely restricting production of an appropriate amount of timber products.

In addition, the above soil mitigations and design features meet the full intent of relevent objectives and standards in the Forest Plan for the Gallatin National Forest. All of the above are designed to address the Forest Plan's objective for mitigating "impacts occurring to the watershed resource from land use activities." Minimizing soil erosion in treatment units through soil mitigations also helps meet the Forest Plan objective for "meeting State water quality standards."

Relevent Forest Plan directives are: 8.b.1.c. "maintain an adequate nutrient pool for long-term site productivity through the retention of topsoil and soil organisms." 10.8. All management practices would be "designed or modified as necessary to maintain land productivity and protect beneficial uses." and 14.4. Treatment of natural fuel accumulations to support hazard reduction and support management area goals would be continued. Compliance with Forest Plan direction ensures that the project is consistent with the National Forest Management Act (1976).

All of the proposed treatment alternatives would meet the Region One standard for limiting activity related detrimental soil distubance of less than 15% DSD at the end of the project. Soils are not a critical resource issue for this project and no extreme soil remediation actions would be required to maintain DSD levels well within allowable levels of disturbance. The Soil Scientist for the Gallatin National Forest would need to be involved, however, in certain implementation aspects of this project. The No Action Alternative (Alternative 1) may have the highest likelihood for negatively impacting soil productivity and the integrity of Bozeman's Municipal Watershed if severe wildfires burn through the area.

Issue: Water Quality

Changes between the FEIS and SFEIS

This SFEIS water resource analysis replaces the water quality analysis in the FEIS on pages 3-31 to 3-52 in its entirety. The revision includes several additions to the FEIS analysis including: additional information for 303(d) and TMDL's (total maximum daily loads) particularly for nutrients in Hyalite Creek, a wetland map of the BMW project area and additional wetland field reconnaissance, City of Bozeman Water Treatment Plant upgrade information, explanation of the NEDC vs. Brown NPDES (national pollution discharge elimination system) lawsuit, potential storm water discharge sites in the BMW, and commitment to stormwater NPDES permit requirements, additional information from field reviews of roads and broadcast units, road decommissioning with associated sediment model adjustments, added Disturbed: Water Erosion Projection Project (WEPP) Tool modeling evaluation and sediment model coefficient adjustment of thinning and broadcast units, added WEPP: Road modeling for logging road sediment source points, additional analysis of sediment effects of large wildfires in the BMW area, added cumulative effects analysis for potential City of Bozeman fuels thinning in Bozeman Creek, addition of recent fuel treatment implementation monitoring reviews, recommended more intensive broadcast burn mitigation measures for Alternative 6, more detailed description of Clean Water Act compliance requirements, and additional water quality monitoring.

Issue

The BMW project is designed to help protect the City of Bozeman's municipal water supply. The issue is the long term tradeoff of risking potentially severe wildfire and associated high sediment increase risk compared to the activities of this proposal and possible short term increases in sediment to the City of Bozeman water treatment plant.

Proposed fuel treatments along with the cumulative effects of existing roads, new temporary roads, and recreation could have an adverse effect on water quality by introducing additional sediment to Hyalite Creek, Bozeman Creek, and Leverich Creek. Increased nutrients in streams may occur from prescribed burns. Increased sediment delivery could have adverse effects on stream channel conditions, water quality, aquatic habitat, and/or downstream beneficial uses.

Indicator

A management indicator for water quality is sediment yield as modeled in tons/year and percent over natural in Bozeman, Hyalite, and Leverich Creeks and primary tributaries. An additional indicator is water yield increase in acre feet and % over natural increase.

Scale of Analysis

The geographic and temporal scale of water quality analysis consists of cumulative sediment modeling of all National Forest and private lands, roads, and recreational developments in the watershed shown in Figure 9. The R1R4 model was used for sediment analysis for all activities from 1980 to 2016 at an accounting point for Hyalite

Creek at the City of Bozeman water intake, Bozeman Creek at the City of Bozeman water intake, and Leverich Creek at the Gallatin NF forest boundary. The 1980 to 2016 period includes primary road construction in the drainages through anticipated BMW water effects.

Summary

Bozeman and Hyalite Creeks are the major sources of water supply for the City of Bozeman. The City has water intake diversions on both streams near the Forest boundary with pipelines to the City Water Treatment Plant near the Bozeman Creek trailhead. Water quality in both Bozeman and Hyalite Creeks is good and in compliance with water quality standards. The Montana DEQ water quality standards for both drainages are very restrictive. Bozeman Creek is designated as A-Closed and Hyalite Creek as A-1. These are non-degradation classifications with very strict controls on turbidity and non-point sources.

Wildfire related ash deposits and sediment in Bozeman and Hyalite Creeks due to increased erosion in wildfire areas is a major potential source of contamination to Bozeman's water supply. A large wildfire in Hyalite and Bozeman watersheds could result in short to long term loss of water supply from a few days to several weeks. The City of Bozeman Water treatment plant has a treatment output capacity of 15 million gallons/day with average use of about 4-5 million gallons/day, winter use 2-4 gallons/day, and peak summer use of about 12-14 million gallons/day. The treatment plant uses a direct filtration process, including flocculation followed immediately by filtration and chlorination. Although the water treatment plant is designed to remove suspended sediment and particulates, rapid shifts in sediment and turbidity and high levels of particulates create treatment difficulty and under severe circumstances would not allow treatment. The Bozeman City Commission has endorsed a Facility Master Plan preferred alternative which is the construction of a 22 million gallon per day filtration plant ultimately expandable to 36 million gallons per day by adding additional membrane filter rods. The Water Treatment Plant initiated pilot testing of the membrane filter technology during 2007 with the goal of construction of the membrane filtration plant as early as 2013.

The SFEIS includes information for 303(d) and TMDL's (total maximum daily loads) particularly for nutrients in Hyalite Creek, a wetland map of the BMW project area and wetland field reconnaissance, road decommissioning with associated sediment model adjustments, Disturbed:WEPP modeling evaluation and sediment model coefficient adjustment of thinning and broadcast units, WEPP:Road modeling for logging road sediment source points, analysis of sediment effects of large wildfires in the BMW area, cumulative effects analysis for potential City of Bozeman fuels thinning in Bozeman Creek, and water quality monitoring.

Applicable water quality laws, regulations, the Montana DEQ 2008 and 2010 303(d) and TMDL preparation process and status, and Forest Plan Guidance are detailed in the Affected Environment section of the SFEIS. Projected sediment level increases in the preferred alternative have been mitigated to be very low and not readily measurable with conventional sediment measurement equipment. The preferred alternative maximum increase in Bozeman Creek sediment of 1.3% with maximum total increase of 4.7% over natural, maximum increase in Hyalite Creek of 1.4% with maximum total increase of

4.9% over natural, and maximum increase in Leverich Creek, of 1.3% with maximum total increase of 5.7% over natural are well within compliance with the Gallatin NF 30% over natural standard for municipal watersheds or sensitive streams.

The preferred alternative meets all applicable water quality laws and standards, regulations, and Forest Plan Guidance for Bozeman Creek, Hyalite Creek, and Leverich Creek.

Affected Environment

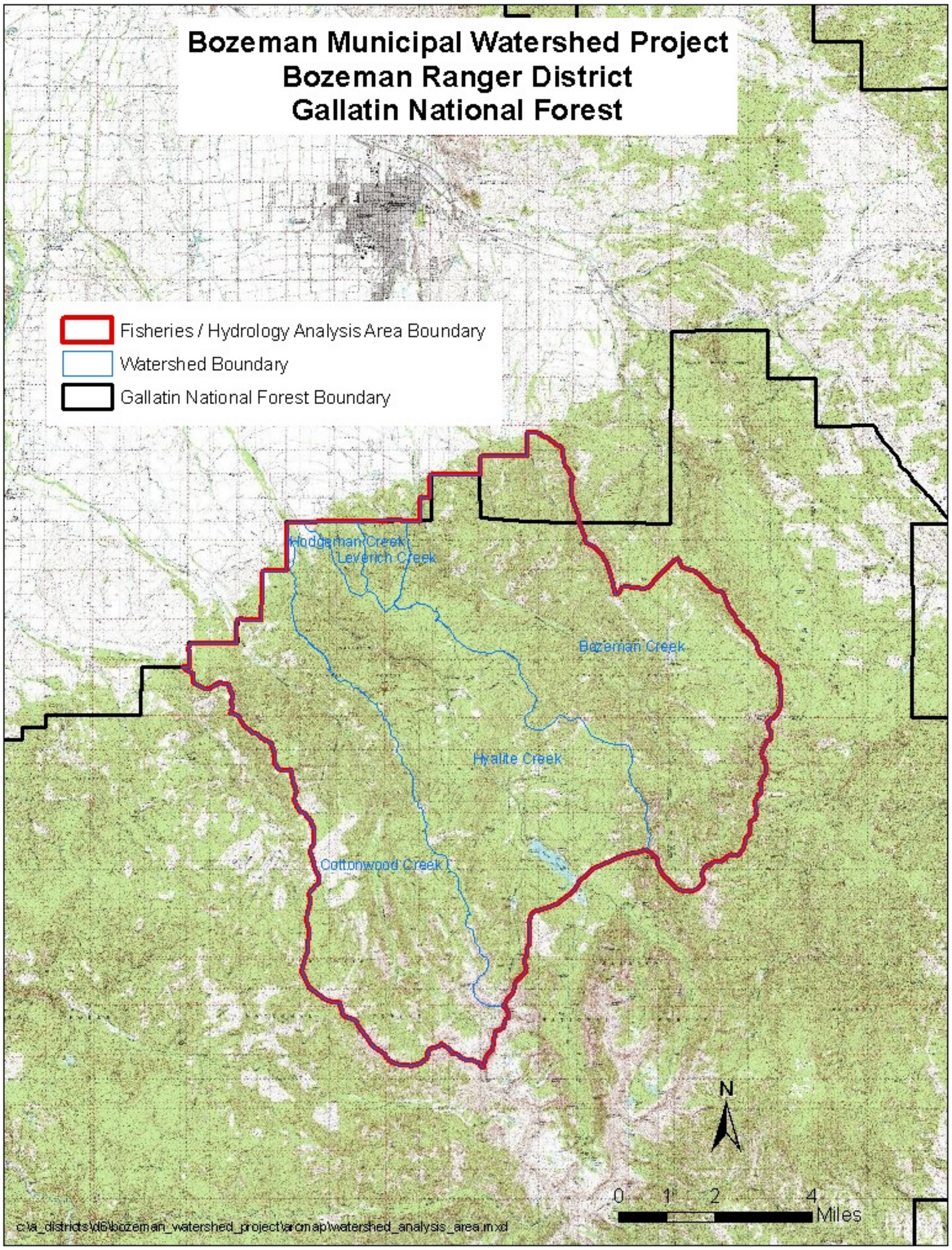
Hyalite Creek. The Hyalite Creek drainage above the City of Bozeman water intake (which is near the USGS stream gate and internal forest boundary) includes 30,700 acres (48.2) square miles. The USGS operated gage # 06050000 near the Forest Boundary (about 0.25 mile above the water intake) from 1934 to 1995. Data from the site is available at: http://waterdata.usgs.gov/mt/nwis/sw .

Average water discharge at the gage site was 65 cfs with a peak flow of 938 cfs measured on 5/22/1981. Average annual water yield for the Hyalite drainage is about 47,000 acre feet per year at the Forest boundary. Approximately 845 acre feet or 1.8% of this is attributable to water yield increase associated with the past timber harvest units and existing roads in the Hyalite drainage. Most of the stream flow occurs as snowmelt runoff, with peak stream flow usually in late May or June. During the last several years warmer than average temperatures in May have resulted in peak snowmelt stream flows in May rather than June on the Gallatin NF. During snowmelt water quality monitoring in 1991 and 1992 discharge near the Forest boundary averaged 155 cfs in 1991 (range from 20 to 309 cfs), and averaged 170 cfs in 1992 (range from 32 to 475 cfs). Average annual precipitation varies from 25" at the Forest Boundary to 50" at the head of the watershed. Average annual snowfall similarly ranges from 125 inches to 300 inches.

The Hyalite drainage, along with Bozeman Creek serves as a major water supply source for the City of Bozeman. The Montana DEQ has designated Hyalite Creek as an A-1 Classification (Administrative Rules of Montana, 2006, section 17.30.610 A-1) at http://www.deq.mt.gov/dir/Legal/Chapters/CH30-06.pdf The A-1 Classification is designed for municipal watersheds, and does not allow increases above naturally occurring concentrations of water pollutants (such as sediment, turbidity, oils, or sewage). The Montana water quality rules define naturally occurring as "conditions or material present from runoff or percolation over which man has no control or from developed land where all reasonable land, soil and water conservation practices have been applied. Conditions resulting from the reasonable operation of dams in existence as of July 1, 1971 are natural."

The 2010 Montana 303(d) database now has 3 stream segments of Hyalite Creek listed http://cwaic.mt.gov/query.aspx. Segment MT41H003-129, a 7 mile segment above Hyalite Reservoir and MT41H003-130, an 8.8 mile segment between Hyalite Reservoir and the City of Bozeman water intake, is listed as partially supporting aquatic life, cold water fishery and primary contact recreation due to chlorophyll-a, total phosphorus, and total nitrogen from rangeland grazing, silviculture harvesting, and unpaved roads and trails. A TMDL for these segments is currently in progress with an anticipated release date of December 2011. MT41H003-132, a 20.4 mile segment below the water intake is listed as partially supporting primary contact recreation due to low flow alterations from dewatering due to irrigated crop production. A TMDL for this segment is not required although the Hyalite Creek segments will be included in the Lower Gallatin TMDL which is currently scheduled to be completed in 2011.

Figure 9. Bozeman Municipal Watershed Boundaries – Watershed Analysis Boundaries.



In addition, the 2010 Montana 303(d) database has Hyalite Reservoir listed as MT41H003-131 but is shown on the database as not currently assessed. The Montana DEQ (Schade, personal correspondence, 2010) based the 303(d) listings on 2004 and 2005 data which are being updated by the Montana DEQ with more intensive monitoring data collected from 2006 to 2010. For example no livestock grazing occurs in MT41H003-129, phosphorous levels are similar throughout Hyalite Creek (including above Hyalite Reservoir) and the Montana DEQ is questioning the impairment cause listing of roads and silvicultural activity as the source of elevated nitrogen in Hyalite Creek (Schade, personal correspondence, 2010).

A proliferation of filamentous green algae occurs in Hyalite Creek immediately below the reservoir and decreases to only sporadic levels within 4 miles. The primary nutrient (nitrogen) source in Hyalite Creek appears to be from Hyalite Reservoir releases. Marcus (1989) and Truelson and Warrington (1994) discuss the potential nutrient enhancing effect of reservoirs specifically including Hyalite Reservoir. Marcus (1989) studied periphyton communities downstream of Hyalite Reservoir and documented dense growth of green algae which carpeted the stream bed immediately below the dam. Marcus also found an increase in periphytic chlorophyll-a in the organic accumulations and increased diatom species diversity. Ammonia-nitrogen and total-nitrogen concentrations correlated with periphyton growth sites with the richest sites immediately below the reservoir. Marcus (1989) suggested that nitrogen fixed by algae in Hyalite Reservoir becomes available for downstream release in the form of ammonia, which is the preferred form of nitrogen by algae in a nitrogen limited system such as Hyalite Creek. Marcus summarized that the nutrient enriching discharge of Hyalite Reservoir was the major influence on periphytic growth. Net productivity of the site immediately below the reservoir averages 4 times greater than for 3 sites further downstream and Marcus concluded that the reservoir supplied nitrogen was rapidly depleted by benthic algae below the reservoir.

Schade (personal correspondence, 2010), speculated that the reservoir nutrient source is organic matter which enter the reservoir from annual water fluctuations with a large area of terrestrial organic input at the inlet areas and associated flat areas which are inundated as the reservoir fills to capacity each spring (May and June). Montana DEQ water monitoring in Hyalite Reservoir (2006-2010) and outlet has validated the high ammonia levels below the reservoir and subsequent assimilation by algae resulting in reduced ammonia levels downstream but increases in measurable nitrate. Schade attributes the ammonia nitrogen source to the reservoir and not to roads, silviculture, or livestock grazing. The Montana DEQ is currently re-assessing the Hyalite TMDL nutrient listing and in the 2011 release of the Hyalite TMDL may consider the nutrient output from the reservoir as "naturally occurring" since the A-1 Classification http://www.deq.mt.gov/dir/Legal/Chapters/CH30-06.pdf states that "Conditions resulting from the reasonable operation of dams in existence as of July 1, 1971 are natural."

The Hyalite Creek watershed contains about 80 miles of roads which are listed in the Gallatin NF Travel Plan. About 35 miles of the roads are open to the public (with various seasonal restrictions). The remainders are project roads which are not open to public travel. In 2010 about 19 miles of roads in the Hyalite drainage were decommissioned through a combination of rip/drain/seed/slash, recontouring, buck and pole fence construction, slash closures, and rock closures. In addition about five miles of unauthorized user made roads and ATV routes were obliterated. Many of the roads selected for decommissioning were eroding and potential sediment sources to Hyalite Creek. Sediment modeling of the extensive 2010 road obliteration estimates that the Hyalite drainage % over natural sediment yield in the BMW analysis area has been reduced from 5.8 to 3.6% over natural.

Figure 10. Re-contoured road segment in Hyalite Creek completed in August 2010. The re-contouring technique is designed to stop road erosion and sediment, and restore slope hydraulics for both ground water and surface water interception. The re-contoured segments are seeded and slashed with removed culvert areas heavily mulched. Initial grass germination was robust. The decommissioning eliminated 19 miles of roads in Hyalite Creek as erosion or sediment sources.

Tributary channels and the mainstem of Hyalite Creek were surveyed for channel stability (Pfankuch, D.J., 1975, Stream Reach Inventory and Channel Stability Evaluation, USFS, R1) and stream typing (Rosgen, 1996). Hyalite Creek is a very stable A2/A3, B3/B4, and C3/C4 steam type with boulder/cobble /gravel stream substrate with generally stable coarse textured stream banks and considerable resistance to erosion and stream channel source sediment. Hyalite Reservoir (storage capacity of 8,000 acre feet, surface area of 206 acres) regulates the stream flow in Hyalite Creek with moderate peak flows resulting in considerable bank vegetation and stable stream channels. Most of the tributary streams to Hyalite Creek are steep, stable, coarse textured A2 to A3 and B2 and B3 channel types (Rosgen, 1996) with limited sediment supply. A few B4 stream channel types occur in the Hyalite Creek watershed which has some unstable and erosive sections. These include sections of Moser Creek, Buckskin Creek, Lick Creek, and Wild Horse Creek.

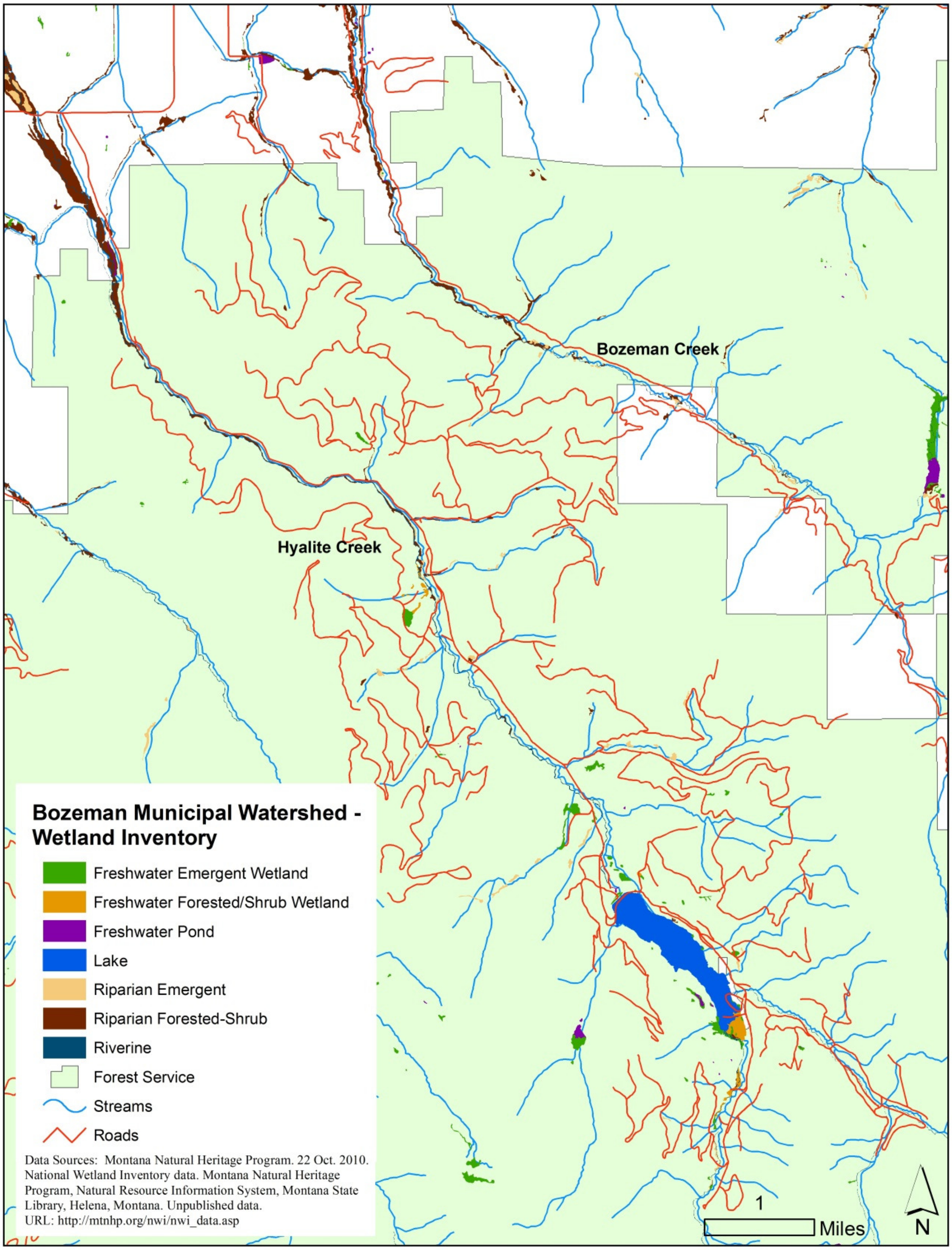
The existing channel of Hyalite Creek below the Reservoir has a very coarse textured composition which indicates Reservoir historical flows have been sufficient to prevent a buildup of excessive fine material (silt, sand, and small gravel).

Water quality in Hyalite Creek is excellent and in compliance with Montana A-1 Classification Water Quality Standards. Glasser (1982, Water Quality on the Gallatin Forest) and turbidity data gathered in 1986 (associated with the first phase of the Hyalite Canyon road reconstruction and paving project) indicated low suspended sediment concentrations (average of 11 mg/l with a range of 1 to 51 mg/L), turbidity average of about 4 NTU (range of 0 to 43 NTU), specific conductance average of 122 mhos (range of 62 to 210), and pH about 7.5 (range 7.1 to 8.6). During 1991 and 1992, Hyalite Creek was monitored at Langor Campground and near the Forest boundary from mid-April through June. Suspended sediment averaged 9 and 17 mg/l (range from 0.5 to 57 mg/L) while bedload sediment averaged 0.8 and 2.4 tons/day (range from 0.0054 to 38.4 tons per day). These are relatively low sediment yield amounts. The water is considered soft (less than 75 mg/l) and low in sodium (less than 2.5 mg/l), which is excellent for municipal watershed purposes. Current Hyalite Creek water quality is slightly better than the 1992 monitoring indicates, since virtually no timber harvest has occurred and several miles of road have been closed and/or decommissioned.

The only grazing allotment in the BMW area is the Hyalite Canyon allotment. This allotment was put into a new management plan in 1998 (USFS, 1998). The allotment plan consolidated the Hyalite and West Hyalite Allotments, eliminated the South Cottonwood allotment, and brought the allotment into compliance with Forest Plan standards. The revised AMP includes 382 AUMs under a three-pasture rest rotation grazing system in 3 pastures (Langohr, Lick/Wildhorse, and Moser/Buckskin). A riparian exclosure fence of approximately 1/2 mile in length has been constructed to eliminate the riparian utilization issues in Lick Creek. Buckskin Creek riparian grazing has been virtually eliminated with the implementation of livestock grazing best management practices and adherence to riparian utilization standards. The increased riparian buffering from the new pastures and exclusion fencing has increased sediment infiltration and has reduced water quality effects to very minor and probably un-measurable.

Hyalite, Bozeman, Leverich, Hodgeman, and South Cottonwood Creek areas in the BMW project are well drained with only a few localized areas which would be considered wetlands. The Montana Heritage Program, Natural Resources Information System, Montana State Library http://mtnhp.org/nwi/nwi_data.asp wetland map layer is shown in Figure 11 and includes freshwater emergent wetlands, freshwater forested/shrub wetlands, freshwater ponds, lakes, riparian emergent, riparian forested – shrub and riverine wetlands. Figure 11 includes the Montana Heritage Program wetlands with the Gallatin NF stream layer added in because some localized riverine wetlands not shown on the Montana Heritage Program maps could occur on the lower gradient reaches of streams. These wetlands consist of three general types: (1) lakes, (2) seeps and springs, and (3) streamside areas. A few small bogs in the area are classified as palustrine emergent wetlands. The seeps, springs, and streamside areas are classified as riverine, upper perennial wetlands (Cowardin et. al., 1979). The seeps and springs are perennially saturated, while most of the streamside areas are only seasonally saturated (usually during snowmelt runoff). The largest concentration of wetlands occur in the upper end of Hyalite reservoir (freshwater forested/shrub wetland) and in lower Hyalite and Bozeman Creeks (riparian forested/shrub wetlands) neither of which are in the BMW project area. Most of the wetlands within the BMW project area are freshwater emergent wetlands (which are not in any road or thinning or broadcast burn treatment units) or riverine wetlands near or adjacent to existing roads. Project activity wetlands disturbance will be avoided in BMW project implementation, with implmentation of water quality protections in Appendix A and application of a standard operating practice that excludes wetlands within units during marking and presale preparation work.

Figure 11. Bozeman Municipal Watershed project area wetlands.



Bozeman Creek   Bozeman Creek drainage above the City of Bozeman water intake (which is near the USGS stream gate and internal forest boundary) includes about 22,000 acres (34.4) square miles. The Montana DEQ has designated Bozeman Creek as an A-Closed Classification (Administrative Rules of Montana, 2010, section 17.30.610 A-1) at http://www.deq.mt.gov/dir/Legal/Chapters/CH30-06.pdf . Bozeman Creek is the only A-Closed watershed on the Gallatin NF. The A-Closed classification is designed to protect municipal watersheds with access restrictions to protect public health. No change above "naturally occurring" turbidity or sediment is allowed. The Montana water quality rules at http://www.deq.mt.gov/dir/Legal/Chapters/CH30-06.pdf define naturally occurring as "conditions or material present from runoff or percolation over which man has no control or from developed land where all reasonable land, soil and water conservation practices have been applied." For the BMW project this means that water quality changes are naturally occurring providing strict BMP's are followed.

Water quality in Bozeman Creek is good and meets State of Montana A-Closed standards. The Paleozoic parent material in the upper end of the watershed and Precambrian crystalline parent material in the lower end of the drainage (granite, gneiss) produces water which is moderately hard (55 to 140 mg/l), low in alkalinity, with a pH range of 7.0 to 8.4 and a fluoride range of 0 to 0.1 mg/l. Average TDS was 150 mg/l and average specific conductance was 194 micromhos. Gallatin NF monitoring indicated that annual sediment yields averaged 25.6 tons/mile^2/year from 1978 through 1980. Since that time the amount of timber harvest activity in Bozeman Creek has declined and average annual sediment yields are lower, currently estimated at 12.8 tons/mile^2/year. Current sediment yields, evaluated with the R1R4 model, and accounting for all existing roads and harvest units, indicated that Bozeman Creek sediment yields are about 3.4% above a pristine baseline which is well within the Gallatin NF sediment standard for a Class A stream of 30% over natural.

The 2008 Montana 303(d) database has a lower segment of Bozeman Creek listed, (http://cwaic.mt.gov/query.aspx) MT41H003-040. This segment is a 4.7 mile segment from Limestone Creek to the East Gallatin River, which initiates about 3 miles below the City of Bozeman water intake. This section of Bozeman Creek is listed as partially supporting aquatic primary contact recreation but not supporting aquatic life and cold water fishery due to stream alteration, chlorophyll-a, escherichia coli, total phosphorus, and total nitrogen from a variety of agricultural and urban sources including channelization, riparian grazing, irrigated crop production, loss of riparian habitat, septic disposal, and yard maintenance. This segment will be included in the East Gallatin TMDL which is currently scheduled to be completed between late 2011 and 2012.

Average annual water yield for the Bozeman Creek drainage is about 21,400 acre feet. Approximately 210 acre feet or about 1% of this total is increased water yield associated with the existing timber harvest units and roads. This amount of water yield is immeasurable and is insufficient to result in stream channel scour from water yield increase. Most of the streamflow occurs as snowmelt runoff, with peak stream flow usually in June. May and June account for about 50% of the yearly streamflow in Bozeman Creek. The watershed receives an average of about 29 inches of precipitation annually on an area-weighted basis. Based on yearly climatic records, there is about a 25% variation in this figure for two-thirds of the years. Average annual precipitation varies from about 25" at the Forest Boundary to about 50" at the head of the watershed. Average annual snowfall ranges from about 125 inches to 275 inches.

Bozeman Creek channel stability is generally good through the Forest Boundary. Bozeman Creek alternates between Rosgen (1996) B3 and C3 channel types in the lower reaches above and below the City of Bozeman water diversion. The riffle dominated B3 channel type has moderate entrenchment, and a cobble dominated 2-4% gradient. The riffle/pool C3 channel type is slightly entrenched with a cobble dominated, 1-2% gradient. Channel stability is good (CSR score of 70 above the City diversion). A few C4 channel segments occur in the upper part of the Bozeman Creek watershed.

The City of Bozeman has substantial and senior water rights to Bozeman Creek. Since Mystic Lake Reservoir was breached in the early 1980's, no water storage in the drainage occurs. The City of Bozeman could increase late season water supply by construction of an impoundment for which the City has reserved storage rights with the Montana DNRC. The City has retained a consultant to prepare a study of out year Bozeman water needs and availability of ground water and surface sources. If the City proposes a storage impoundment in Bozeman Creek an analysis would need to evaluate the environmental impacts in which potential water resource related cumulative effects would need to be disclosed.

Figure 12. Rehabilitation trail and road work in 2008 and 2009 reduced Leverich Creek sediment considerably from pre-project sediment model estimates of 8.4% in 2008 to 4.4 % over natural in 2010. This photo was taken at the Leverich Creek trailhead. The road in the background was re-contoured in 8/2008 with the photo taken on 8/2009 with elimination of the road segment as a sediment source to Leverich Creek.

Leverich Creek Leverich Creek is a small, 1470 acre watershed (2.3 mi^2), with a moderate gradient (2-4%). Fish habitat in Leverich Creek is described in the fishery report. No specific water quality data is available for Leverich Creek. The main water quality existing impacts to Leverich Creek are the lower road and trail and associated recreational use. Rehabilitation trail and road work in 2008 and 2009 reduced Leverich sediment considerably from a pre-project sediment model estimate of 8.4% over natural to 4.4% over natural, see Figure 12. All streams evaluated in detail are Category A (see below) due to the presence of Westslope Cutthroat trout in Leverich Creek or municipal watershed designations for Bozeman Creek and Hyalite Creek. Hyalite and Bozeman Creek are HUC6 watersheds while Leverich Creek is a HUC7 watershed. South Cottonwood and Hodgeman Creeks are Category B streams.

<u>City Water System</u> The City of Bozeman Source Water Protection Plan (City of Bozeman, 2006) and Sourdough Creek Watershed Assessment (Bozeman Watershed Council, 2004) provide extensive background information on watershed condition of Hyalite and Bozeman Creeks. The Water Protection Plan provides information about water production from Bozeman and Hyalite Creeks, City of Bozeman Water Treatment Plant and out year water use projections, and the need for an upgraded water treatment plant. The Bozeman Source Water Protection Plan (City of Bozeman, 2004) lists wildfire as the highest priority impact for the Hyalite and Sourdough (Bozeman) watersheds.

The Bozeman Water Treatment plant is constrained by turbidity considerations in treating incoming water and meeting operational standards. Analysis of the 1992 snowmelt runoff water quality data at the mouth of Hyalite Canyon (summarized in the Affected Environment section above) indicates that peak turbidity (13 NTU or nephelometric turbidity units) occurred on the same date as peak suspended sediment (32 mg/L) and the lowest turbidity levels (2-4 NTU) coincided with the lowest suspended sediment measurements (0.5 to 5 mg/L). Regression of the 1992 Hyalite Creek turbidity with suspended sediment indicated a correlation coefficient (R^2) of 0.79 with the largest variability in the lower NTU and suspended sediment ranges. The Bozeman Water treatment Plant incoming NTU generally ranges from 1-7 NTU and outgoing NTU around 0.04 NTU. The EPA water treatment standard for outgoing turbidity is 0.3 NTU. The Treatment Plant has a difficult time treating water when NTU exceeds 20.

The City of Bozeman Water treatment plant has a treatment output capacity of 15 million gallons/day with average use of about 4-5 million gallons/day, winter use 2-4 gallons/day, and peak summer use of about 12-14 million gallons/day. The treatment plant uses a direct filtration process, including flocculation followed immediately by filtration and chlorination. Although the water treatment plant is designed to remove suspended sediment and particulates, rapid shifts in sediment and turbidity and high levels of particulates creates treatment difficulty. Under severe circumstances the plant manager would temporarily shutdown the intake. Wildfire related ash deposits and sediment in Bozeman and Hyalite Creeks due to increased erosion in wildfire areas is a major potential source of contamination to Bozeman's water supply.

A large wildfire in the Hyalite and Bozeman watersheds could result in short to long term loss of water supply from a few days to several weeks. The most at risk situation would be heavy rainfall within 2 years of a major wildfire. In the event of temporary closure of the treatment plant, water could be rationed from the storage tank on the east side of Bozeman with about a 3 day supply if carefully used. In a prolonged severe shutdown, Bozeman residents may need to use bottled water until the treatment plant resumes operation. The City commissioned a facility plan evaluation of the treatment plant with the long term potential to convert from direct filtration to conventional or membrane filtration. The City of Bozeman Water Facility Master Plan (City of Bozeman, 2006) contains an extensive analysis of potential water treatment upgrade alternatives.http://www.bozeman.net/bozeman/engineering/documents/Water_Facility_Plan.pdf . The Bozeman City Commission endorsed the Facility Master Plan preferred alternative which is the construction of a 22 million gallons per day filtration plant, ultimately expandable to 36 million gallons per day by adding additional membrane filter rods. A raw water storage pond, which could be used to store up to a week of water in case wildfire compromised raw water quality, was not endorsed by the City of Bozeman due to excessive cost. The Water Treatment Plant initiated pilot testing of the membrane filter technology during 2007 with the goal of construction of the membrane filtration plant as early as 2013. Although this technology would be more effective at reducing turbidity from ash and sediment than the current technology, water treatmentwould still be difficult for the system in the event of large influxes of sedimeent and ash.

Applicable Laws, Regulation, and Forest Plan Direction

The State of Montana Water Quality Act requires the state to protect, maintain, and improve the quality of water for a variety of beneficial uses. Section 75-5-101, MCA established water quality standards based on beneficial uses. The Montana Department of Environmental Quality has designated Bozeman Creek as A-Closed, Hyalite Creek A-1, and Leverich Creek, Hodgeman Canyon, and South Cottonwood Creeks as B1 Classification http://www.deq.mt.gov/dir/Legal/Chapters/CH30-06.pdf. Waters classified as A-Closed must be suitable for drinking, culinary, and food processing purposes after conventional treatment; bathing, swimming and recreation; growth and propagation of salmonid fishes and associated aquatic life although access restrictions to protect public health may limit actual use of A-Closed waters for these uses. No increase above naturally occurring dissolved oxygen, pH, turbidity, or temperature is allowed.

Waters classified as A-1 must be suitable for drinking, culinary, and food processing purposes after removal of naturally present impurities. No increase above naturally occurring dissolved oxygen, pH, turbidity, or temperature is allowed. Waters classified as B1 must be suitable for drinking, culinary, and food processing purposes after conventional treatment; bathing, swimming and recreation; growth and propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply. A 5 NTU turbidity increase above naturally occurring turbidity is allowed in B1 waters. The Montana water quality standards (ARM 17.30.602 (19)) define naturally occurring as “conditions or material present from runoff or percolation over which man has no control or from developed land where all reasonable land, soil, and water conservation practices have been applied”. The Montana water quality standards (ARM 17.30.602 (25)) define reasonable land, soil, and water conservation practices as “means, methods, measures, or practices that protect present and reasonably anticipated beneficial uses. These practices include but are not limited to structural and non-structural controls and operation and maintenance before, during, or after pollution producing activities.” http://www.deq.mt.gov/dir/Legal/Chapters/CH30-06.pdf .

These Montana water quality standards require the use of effective BMP's so that water quality changes, if any, would be considered "naturally occurring".

Forest Plan

Sediment standards for the Gallatin NF are listed in Table 35. In watersheds with streams currently at or above fish habitat management objectives, proposals for road and trail construction, reconstruction and maintenance are designed to not exceed annual sediment delivery levels in excess of those in Table 35. Sixth-code Hydrologic Unit Codes (HUCs) are the analysis unit for sediment delivery (and other habitat parameters), except where a sixth code HUC artificially bisects a watershed and is therefore inadequate for analysis of impacts to aquatic habitat and aquatic organism meta-populations. In such cases, appropriate larger units will be analyzed (e.g. 5th code HUCs). Within the analysis unit, sediment delivery values in Table 35 will serve as guidelines; however, sediment delivery values denoted in individual 7th code HUCs may temporarily exceed sediment delivery rates denoted in Table 35, in the following circumstances:

- The HUC does not contain a fragmented sensitive or MIS fish population;
- The majority of HUC's in the analysis unit remain within sediment delivery values listed in Table 35;
- Other core stream habitat (e.g. pool frequency, pool quality) or biotic (e.g. macro-invertebrates, fish populations) parameters within the HUC do not indicate impairment as defined by Montana Department of Environmental Quality (MDEQ); and
- Sediment delivery levels will return to values listed in Table 35 within 5 years of project completion.

Table 35. Substrate sediment and sediment delivery by Forest stream category.

Category	**Management Objective (% of reference*)**	**% Fine Substrate Sediment (<6.3mm)**	**Annual % > Reference** Sediment Delivery**
A Sensitive Species and/or Blue Ribbon fisheries	90%	0 – 26 %	30%
B All other streams (formerly Classes B, C, D)	75%	0 – 30 %	50%

*% of reference = % similarity to mean reference condition; reference conditions range = X-Y.

**Reference = observed relationship between substrate % fines and modeled sediment delivery in reference (fully functioning) GNF watersheds.

Gallatin National Forest Plan standards that directly apply to BMW are on pages I-23 and 24 of the Gallatin Forest Plan and include:

Water and Soils:

Best Management practices (BMP's) will be used on all Forest Watersheds in the planning and implementation of project activities.

Require a watershed cumulative effects feasibility analysis of projects involving significant vegetation removal, prior to including them on implementation schedules, to ensure that the project, considered with other activities, will not increase water yields or sediment beyond acceptable limits.

In municipal watersheds, such as Bozeman, Hyalite, and Lyman Creek drainages, all project activities will be implemented to ensure State and water quality standards will be met. Coordination with City of Bozeman officials and the State Water Quality Bureau [now Montana DEQ] will be done throughout the project planning process.

Stormwater discharge

All required water quality permits would be acquired by the Gallatin National Forest prior to any ground disturbance activities for the BMW. If logging road stormwater discharge NPDES permits are required for the BMW Project, the Gallatin National Forest will work with the Montana DEQ to obtain the permits prior to initiation of project implementation. See the water quality specialists report (Story, 2010) for more specific stormwater discharge information relative to the BMW project.

Methodology for Analysis

Potential effects of the Bozeman Municipal Watershed Project were analyzed by an assessment of potential sediment yield from prescribed burn projects and evaluation of low severity spring burns on the Gallatin NF. The effects of mechanical fuel reduction and temporary roads were also evaluated based on sediment modeling and observations of fuel reduction techniques and results on the Gallatin NF. Sediment yield levels for each alternative were evaluated using the R1R4 sediment model (Cline et al. 1981) and adjusting sediment coefficients based on existing road and timber harvest unit acres and conditions. Road sediment for roads used for log hauling was adjusted upward to account for increased sediment potential from log truck road prism impacts. Roads decommissioned in 2010 as well as roads with improved BMP's in 2010 from increased road drainage dips and armored dips were also adjusted accordingly. Baseline sediment yield coefficients are based on sediment monitoring data on the Gallatin National Forest from 1970 to 2010. Between the FEIS and this SFEIS additional field review of road drainage and burn units, and Water Erosion Projection Project (WEPP) Tool sediment coefficient modeling allowed refinement of several of the R1R4 modeling coefficients particularly sediment delivery. This resulted in generally lower modeled sediment levels for Hyalite Creek, Bozeman Creek and Leverich Creek than reported in the FEIS. An example of reduced modeled sediment level coefficients between the FEIS and this SFEIS is shown in Figure 13.

Figure 13. This is a photo of FSR# 1762 in the Bozeman Creek watershed on 9/17/10. The road could be used to provide access to post and pole/non-commercial thinning operations. In the FEIS this road was considered to be 24' wide with a sediment delivery ratio of 0.3. Closer examination of the road revealed that it had extensive re-vegetation on the cut and fill slopes and moderate re-vegetation on the road surface. Coefficients were changed to 20' wide with a sediment delivery ratio of 0.2. For this and many other upper slope roads, the revised sediment coefficients are still quite conservative in that they likely over-estimate sediment delivery.

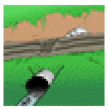
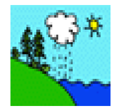
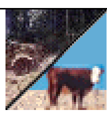
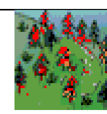
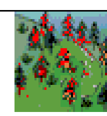
Sediment coefficients levels for many of the same treatment areas were adjusted using procedures in WEPP http://forest.moscowfsl.wsu.edu/fswepp/. The Water Erosion Prediction Project tool (Elliot et al. 2000) was used for sediment delivery modeling and is a conservative approach of estimating potential erosion and sediment effects of timber harvesting, fuels treatments, and roads. The primary WEPP tools used included WEPP:Road for road sediment estimates and Disturbed:WEPP for thinning treatments and broadcast burns.

The WEPP model is a scientifically-based model that predicts what sediment could enter stream courses, or drainages leading to stream courses. WEPP predictions are generally within the range of actual field observations of sediment yields. WEPP predictions represent annual averages of sediment delivery produced by runoff events based on the selected climate and site conditions. In any given year and specific location, erosion values will most likely vary because of site specific conditions and the precipitation regime for that year. Although quantitative values for sediment are generated from this model, results are used as a tool in the interpretation of how complex physical systems may respond. In general, erosion prediction models have difficulty predicting sediment output with precision from a road, hillslope, or watershed at time scales useful to land managers. This is due mainly to a high degree of variability in site characteristics and in climatic variables. An average erosion/sediment delivery rate prediction can encompass this variability to some degree, although this value becomes much more useful when combined with a predicted probability that erosion will occur. The WEPP models deals with the variability by incorporating climate data tailored to the individual site using PRISM data (Daly et al. 2001) and simulates daily events for a number of years specified by the user (30 years in the BMW analysis) to determine the probability of sediment delivery. The model incorporates individual precipitation event characteristics and antecedent conditions as well as site characteristics into its prediction of event-scale runoff, erosion, and sediment yield values.

For this BMW SFEIS, erosion from treatment units was evaluated (with Disturbed-WEPP) using ten-year-return-interval rain events based on fifty years of simulated climate. For the BMW project the WEPP model for prescribed fire and thinning used the Mystic Lake MT 2 climate regimen and 20 year cycles for prescribed fire and thinning. The resulting WEPP output coefficients were similar but slightly lower than the previously used R1R4 thinning and broadcast burning coefficients and were then used to adjust the R1R4 coefficients which enabled a closer comparison evaluation of watershed sediment yield effects, alternative comparisons, and sediment standard compliance.

WEPP:Road was used to estimate road sediment changes from increased log truck use. Potential stormwater discharge points were identified in field surveys on September 17-21, 2010. For each site the appropriate WEPP:Road parameters were measured (road length, width, gradient, slope gradient and width, buffer gradient and width). The WEPP:Road model incremental logging truck road sediment was deliberately overestimated by assuming that pre-BMW logging road traffic was low, and high during BMW implementation. For Bozeman Creek pre-BMW logging traffic was entered as none and during BMW as high. Since recreation traffic on roads in Hyalite Creek is very high the incremental addition of WEPP:Road sediment model results are conservative (overestimating sediment effects). The WEPP:Road sediment use coefficients were then included in the R1R4 sediment modeled road amounts in Tables 37-42.

Table 36. Forest Service WEPP Interfaces.

	Cross Drain Predict sediment yield from a road segment across a buffer. CrossDrain can be used to determine optimum cross drain spacing for existing or planned roads, and for developing and supporting recommendations concerning road construction, reconstruction, realignment, closure, obliteration, or mitigation efforts based on sediment yield.	Rock:Clime Create and download a WEPP climate file to your PC. The Rocky Mountain Climate Generator creates a daily weather file using the ARS CLIGEN weather generator. The file is intended to be used with the WEPP Windows and GeoWEPP interfaces, but also can be a source of weather data for any application. It creates up to 200 years of weather from a database of over 2600 weather stations and the PRISM 2.5-mile grid of precipitation data.	
	WEPP:Road	WEPP:Road Batch	
	Disturbed WEPP	Tahoe Basin Sediment Model	
	WEPP FuME (Fuel Management)	ERMiT	
		Other WEPP resources	

The R1R4 sediment model was run in a cumulative fashion accounting for all existing roads, timber harvesting, and residential, and recreational developments in the Bozeman and Hyalite watersheds to the City of Bozeman water intake diversions near the Forest boundary. Leverich Creek was modeled to the Forest boundary and includes the sediment reduction in rehabilitation (roads and trails) in the road sediment column for each alternative. Modeling timeframe was from 1980 to 2016 with tabulated results displayed from 2008/2010 to 2016 during the time of road decommissioning and BMW implementation. The R1R4 model used in the sediment analysis is designed to address the cumulative effects of timber harvest operations, road construction, and fire. The model does not attempt to analyze the effects of grazing and mining activities (other than vegetation removal and road construction) or individual episodic storm events. The model is designed to compare relative differences among alternatives rather than to predict precise sediment and water yields that are likely to occur upon project implementation. Because the R1R4 model, like WEPP, relies on climatic conditions over long periods, the models' accuracy is best when averaged over several years. The model is less reflective of individual drought or flood years. The R1/R4 sediment model focuses on slope processes and estimates the water and sediment delivered to the main channel by forest management within the watershed, including the headwater stream channels. However, the routing of sediment and water through the main channel is limited to broadly based regional curves as no main channel hydrologic or hydraulic processes are modeled directly.

Treatment units and associated activities within the Hodgeman Canyon and Cottonwood Creek watersheds were not modeled since proposed treatment units within the Cottonwood Creek watershed are located on the hydrologic divide separating the Cottonwood and Hyalite Creek drainages. Likelihood of direct, indirect and cumulative effects sediment yields in those units is unlikely. Proposed treatment units within the Hodgeman Canyon watershed have very limited potential for sediment increase and are located above several irrigation ditches which do not discharge into Hyalite or Bozeman Creeks.

Potential water yield increase was calculated using a water balance (ECA) method.

Direct and Indirect Effects of Alternative 1 (No Action Alternative)

Under the no action Alternative 1, no fuels reduction actions associated with BMW would be undertaken over the next 5-10 years to respond to the purpose and need identified in Chapter 1. The opportunity to reduce fuel accumulations would be deferred. No treatments such as hand piling, thinning, or broadcast burning would be done. No vegetative treatments would be undertaken to treat stands. No thinning of timber would occur. There would not be any road reconstruction, construction, or road improvements in the project area. No additional prescribed fire treatment sediment or increase in road sediment would occur. All drainages would meet the Category A 30% over natural sediment standard and would be in compliance with Montana Water quality standards. Alternative 1 has the lowest short term potential for turbidity increases at the Bozeman Water Treatment Plant due to fuels reduction treatments. Sediment modeling results for Alternative 1 are shown in Table 37.

Table 37. Sediment yield estimates for Alternative 1 – No Action.

Year	Natural Sediment (tons/year)	Road Sediment (tons/year)	Thinning Sediment (tons/year)	Broadcast Burn Sediment (tons/year)	Total Sediment (tons/year)	% Over Natural Sediment Delivery
Bozeman Creek at Water Intake near Forest Boundary						
2010	354	11.9	0	0	365.9	3.4
2011	354	11.9	0	0	365.9	3.4
2012	354	11.9	0	0	365.9	3.4
2013	354	11.9	0	0	365.9	3.4
2014	354	11.9	0	0	365.9	3.4
2015	354	11.9	0	0	365.9	3.4
2016	354	11.9	0	0	365.9	3.4
Hyalite Creek at Water Intake near Forest Boundary						
2010	533	30.7	0	0	563.7	5.8
2011	533	19	0	0	552	3.6
2012	533	19	0	0	552	3.6
2013	533	19	0	0	552	3.6
2014	533	19	0	0	552	3.6
2015	533	19	0	0	552	3.6
2016	533	19	0	0	552	3.6
Leverich Creek at Forest Boundary						
2008	29.8	2.5	0	0	32.3	8.4
2009	29.8	1.3	0	0	31.1	4.4
2010	29.8	1.3	0	0	31.1	4.4
2011	29.8	1.3	0	0	31.1	4.4
2011	29.8	1.3	0	0	31.1	4.4
2012	29.8	1.3	0	0	31.1	4.4
2013	29.8	1.3	0	0	31.1	4.4
2014	29.8	1.3	0	0	31.1	4.4
2015	29.8	1.3	0	0	31.1	4.4
2016	29.8	1.3	0	0	31.1	4.4

The sediment levels for Bozeman Creek would be unchanged in Alternative 1 from 2010 through 2016 for Bozeman Creek assuming no wildfires occur in the drainage. Hyalite Creek sediment modeling results show a decrease in sediment from 5.8% over natural in 2010 to 3.6 % over natural due to the road decommissioning in 2010 (19 miles). Leverich Creek sediment reductions starting in 2009 are due to rehabilitation work conducted in 2008 and 2009 (trail improvements and trail and road obliteration) with a reduction from 8.4% over natural to 4.4% over natural.

Alternative 1, however, has the highest risk for catastrophic wildfire in the project area which poses extensive potential impacts to soil erosion, debris flows, and sediment loadings to Bozeman Creek, Hyalite, and to a lesser degree Leverich Creek. The no action alternative would forgo the fuels management opportunity to reduce the likelihood of extensive water quality impacts from a large wildfire. The R1R4 sediment model was also used to estimate sediment effects of the initial SIMPPLLE simulations for the Bozeman Creek wildfire risk analysis (USFS, 2003). The modeling assumed that modeled severity fire was a reasonable approximation of fire class.

Estimated wildfire generated sediment in Bozeman Creek peaked at 254% over natural for average conditions and 520% over natural for extreme conditions. Similar sediment response would be expected with a robust wildfire in Hyalite Creek. These modeling numbers are consistent with recent (since 2001) wildfires on the Gallatin where modeled and actual sediment yields after wildfires were frequently 200 – 300 % over natural with extensive impacts to the stream channel system (USFS, 2010a).

Cumulative Effects of Alternative 1

The R1R4 sediment modeling was run for Alternative 1 in a cumulative mode accounting for all existing roads, timber harvesting, residential, and recreational developments in Bozeman, Hyalite, and Leverich Creeks. Timeframe for the cumulative effects analysis is 1980 to 2016. Overall sediment impacts of Alternative 1 would not change unless sediment is increased by wildfires. Since there are no direct or indirect effects, no cumulative impacts with other sediment or nutrient impacting activities in Bozeman Creek, Hyalite Creek, or Leverich Creek would occur.

The City of Bozeman may implement a portion of the Forest Management Plan (Peck 2009) which could include thinning ground based harvest, helicopter harvest, and thinning with about 0.85 miles of temporary roads and up to 4.3 miles of road reconstruction and drainage improvements. Timing of the City treatments is not scheduled. Sediment estimates with the R1R4 model assumes that the City work was done over a 3 year timeframe (same assumption as BMW). The treatments adjacent to the intake in T3S R6E sections 7, 17, and 18 would elevate Bozeman Creek sediment levels by approximately 0.7% in the maximum treatment year. Treatment of all of the City lands including T3S R6E sections 27 and 35 could raise Bozeman Creek sediment by an additional 2% for a total increase of 2.7% over the BMW Alternative 1 (3.4% over natural) for a total of 6.1%.

The DNRC consideration to harvest mountain pine beetle stands in the Bear Canyon area would not cumulatively affect Bozeman Creek sediment in the BMW cumulative effects analysis area because the location is downstream of the Bozeman Creek water intake. Some increased sediment from the DNRC harvesting could occur in Limestone Creek which is a tributary to Bozeman Creek about 4 miles downstream from the City of Bozeman water intake.

The City of Bozeman is conducting feasibility studies for a Bozeman Creek impoundment for municipal water storage above the BMW project area. The dam is not currently reasonably foreseeable and would not be constructed until several years after the 2016 water resource cumulative effects BMW timeframe. If a proposal was presented to the Forest Service, full environmental analysis would be required.

Direct and Indirect Effects of Alternative Two

Alternative 2 has a greater probability for sediment yield increases than Alternative 1 due to BMW treatments including temporary roads, thinning of trees, and broadcast burning. Erosion and sediment increase from the mechanized ground based treatments and timber removal could result from skid trails, log yarding, landings, piling disturbance, temporary roads, and pile and broadcast burns.

Table 38. Sediment yield estimates for Alternative 2.

Year	Natural Sediment (tons/year)	Road Sediment (tons/year)	Thinning Sediment (tons/year)	Broadcast Burn Sediment (tons/year)	Total Sediment (tons/year)	% Over Natural Sediment Delivery
Bozeman Creek at Water Intake near Forest Boundary						
2010	354	11.9	0	0	365.9	3.4
2011	354	12.6	3.4	1.7	371.7	5.0
2012	354	12.6	4.7	2.1	373.4	5.5
2013	354	12.6	7.5	0.4	374.5	5.8
2014	354	12.6	4.0	0.1	370.7	4.7
2015	354	12.6	2.5	0	369.1	4.3
2016	354	11.9	0	0	365.9	3.4
Hyalite Creek at Water Intake near Forest Boundary						
2010	533	30.7	0	0	563.7	5.8
2011	533	19.5	4.7	0.3	557.5	4.6
2012	533	19.5	6.0	0.3	558.8	4.8
2013	533	19.5	7.3	0.4	559.9	5.0
2014	533	19.5	4.5	0.1	557.1	4.5
2015	533	19.5	2.8	0	555.5	4.2
2016	533	19	0	0	552	3.6
Leverich Creek at Forest Boundary						
2008	29.8	2.5	0	0	32.3	8.4
2009	29.8	1.3	0	0	31.1	4.4
2010	29.8	1.3	0	0	31.1	4.4
2011	29.8	4.0	4.1	0	37.9	27.1
2012	29.8	2.9	5.7	0	38.4	33.2

Year	Natural Sediment (tons/year)	Road Sediment (tons/year)	Thinning Sediment (tons/year)	Broadcast Burn Sediment (tons/year)	Total Sediment (tons/year)	% Over Natural Sediment Delivery
2013	29.8	2.9	7.0	0	39.7	29.5
2014	29.8	2.9	4.3	0	37.0	24.1
2015	29.8	1.3	2.8	0	33.9	13.7
2016	29.8	1.3	0	0	31.1	4.4

In Alternative 2, the R1R4 model was run assuming all temporary roads would be constructed in 2011, pre-commercial thinning done during 2011 and 2012, commercial thinning during 2011-2013, and prescribed burning from 2011 to 2013. Delays in project initiation could extend BMW implementation until beyond 2016. It was also assumed that no wildfires would occur during 2010 – 2016 in order to display the potential sediment increases from Alternative 2 activities. The 2.2 miles of temporary road locations in Alternative 2 were examined on the ground in 9/2010 for potential discharge connectivity via intermittent or perennial stream channels to Hyalite Creek. The Alternative 2 temporary roads in the sediment analysis are primarily in 2 segments along the components of unit 22 (S 24 T3S R5E and S 30 T3S R6E). These temporary roads are located in upper hill slope and ridge top locations with no intermittent or perennial stream crossings. The temporary road locations cross some swales which do not have discernable stream channels, are heavily vegetated, and would filter out any thinning related sediment. The remaining temporary roads are in unit 13 (Hodgeman Creek) and on the South Cottonwood/Hyalite Creek divide which are also upper slope locations with no sediment discharge potential. No Alternative 2 temporary roads occur in Bozeman Creek.

The main potential for increased sediment occurs in tractor harvest thinning units as displayed in Table 38. Potential sediment increases in tractor units could be reduced from Table 38 amounts where winter logging could be used for ground based thinning or cable/skyline harvesting. At this time, winter logging is not required but is permissible. The hand treatment and helicopter thinning have very limited potential to increase sediment due to minimal ground disturbance. Pile burns typically consume the duff and upper soil horizon more deeply than understory burns and take longer for re-vegetation. However, the piles are surrounded by unburned areas, which have very short erosion slope lengths which act to contain erosion to the area of the pile. Spring rains in the proposed treatment areas are typically frontal storms of low intensity as opposed to summer storms which usually contain less overall precipitation, but are convective driven with cells of moderate to high intensity. Actual areas of erosion and sediment delivery within the Bozeman Municipal Watershed project area are expected to be minor and very localized, primarily in areas where more intensive storms impact treated areas before revegetation occurs. Alternative 2 would reduce but not eliminate the risk of severe or extensive wildfire as associated potential for sharp sediment increases from precipitation events impacting burned areas.

Bozeman Creek sediment related to BMW would increase from an estimated 3.4% over natural in 2010 to 5.0% in 2011, a 1.6% maximum increase. Hyalite Creek sediment would decrease from an estimated 5.8% over natural in 2010 to a project maximum of

5.0% over natural in 2012. The overall Hyalite Creek decrease is due to the 2010 road decommissioning but the net increase (after decommissioning) is about 1.4%. Alternative 2 sediment levels in Hyalite Creek are projected to decrease to 3.6% over natural by 2016 when the effects of BMW implementation would be through. Leverich Creek sediment would decrease from an estimated 8.4% over natural in 2008 to 4.4% over natural in 2010 but increase to a maximum of 33.2 % over natural in 2012, a 28.8% over natural maximum increase. In reality the implementation of the proposed treatments would likely be spread out over more than 3 years so the peak sediment increase would likely be less. In Bozeman Creek no temporary roads would be built in Alternative 2 so potential sediment increases could occur from thinning treatments and broadcast burning. Leverich Creek sediment reductions starting in 2009 are due to rehabilitation work completed in 2008 and 2009 (trail improvements and trail and road obliteration).

The prescribed broadcast burn could result in localized erosion and soil displacement with associated delivery to stream channels (sediment). The R1R4 modeled broadcast burn sediment increases are very conservative (i.e. overestimating sediment delivery) since no prescribed burn sediment impacts to stream channels have been observed on the Gallatin NF. Based on multiple observations of spring burns on the Gallatin NF, erosion and sediment from spring burns is anticipated to be very minor. Examination of several spring burns on the Gallatin NF within a few months to two years after treatment during the last 16 years has documented very robust re-vegetation of grass, forbs, and shrubs. Spring burns on the Gallatin NF have usually re-vegetated 2-6 weeks after treatment. Implementation monitoring of Gallatin National Forest spring burns (Hyalite Creek Rx burn in 1994, Bozeman Creek and Squaw Creek burns in 1996, Karst Creek in 2005, and Deer Creek in 2006; see Figure 14) have not found any evidence of sheet or rill erosion or stream sedimentation (USFS 1994, USFS 1996, USFS 2005, USFS 2006).

In general spring burns do not attain sufficient heat to result in more than low intensity with pockets of moderate burn intensity. Typically, spring burns result in shallow surface combustion that leaves roots intact. Nutrient mobilization into soil and usually ample soil moisture during March-May often results in robust grass/forb regrowth and shrub re-sprouting. Fall understory burns have a greater potential for erosion since the drier duff conditions usually burn more deeply and the treated areas typically do not revegetate until the following spring. Implementation monitoring of fall burns in Big Creek in 2008 and Dry Fork in 2009 (USFS 2009, USFS 2010b; Figrue 15a and 15b) documented a few areas of moderate burn intensity and some pockets of high burn intensity but only very localized erosion on upper hill slopes at considerable distance from any streams with no areas of sediment deposition to stream channels.

Figure 14. Deer Creek prescribed burn implemented in 5/06, photo in 7/06. This south slope facing burn is typical of many of the proposed BMW prescribed spring burns with quick and robust ground cover regeneration with no observed erosion or sediment impacts.

Figure 15. The Dry Fork burn south of Big Timber, on the Gallatin NF was completed in May and September of 2009. These photos were taken on June 23, 2010. The left side photo is of an area burned in 5/2009 and the right side photo of a unit burned in 9/2009. The watershed response to the Dry Fork burn was thoroughly tested with above average (6") of rain during May and June 2010. No evidence of erosion was found even in the most intensely 9/2009 burned areas. The Dry Fork burn resulted in no evident ash movement or sediment delivery to Dry Fork or ephemeral tributaries. These burn results are also representative of some of the most intensively anticipated burns in the BMW and support the NEPA water conclusions of very limited water resource impact of the proposed BMW prescribed burns.

A water balance technique (ECA method) was run for Alternative 2 to calculate potential water yield increase assuming all mechanical harvesting and broadcast burns would act as clearcuts. The potential water yield increase for Alternative 2 would be an additional 207 acre feet of water yield in Bozeman Creek or 0.9% which combined with the approximately current increase of 1% would result in an increase of 1.9%. Hyalite Creek increase would be an additional 112 acre feet or an increase of 0.2% which combined with the current increase of 1.8% could result in total water yield increase of about 2%. In actuality the partial canopy reduction methods being proposed will result in only an estimated 10-20% of these projected water yield increases but a slightly earlier snowmelt in the thinned units due to the more open canopy. These are much too low of potential changes to be measurable or result in low flow reductions.

A concern with the prescribed burns in BMW is the potential for nutrient enrichment of Hyalite Creek since it is included on the TMDL list for phosphorous and nitrogen. Conversion of organic vegetation to inorganic nutrients and reduced plant uptake after fires can result in increased leaching of nutrients to streams. Nutrient increases in streamflows have been measured in several research watersheds from wildfires – usually most prominently immediately after the wildfire event (Spencer and Hauer, 1991).

The understory and pile burns in the BMW project have considerably less biomass consumption and burning depth than wildfires and would not be expected to have measurable nutrient effects in any of the drainages including Hyalite Creek. Measurable nutrient effects, however, could occur from wildfires. Burning changes the organic matter contained in the above ground vegetation and litter to ash. Under higher fire severities, the duff and upper mineral soil horizons can also be burned. Precipitation may dissolve the ash and carry the chemical elements into the soil as dissolved ions or it can be lost from the site aerially or in surface runoff and sediments. Hotter temperatures will increase the amount of nitrogen volatilized. Nitrogen compounds remaining after fire, particularly ammonium nitrogen (NH_4-N) are available for plant uptake and may increase fertility (as reported in DeBano et al. 1994 and Neary et al. 2005). Hydrologic responses following lower intensity prescribed fire are generally minor when compared to wildfire and in fact are endorsed as mitigation to reduce large nitrogen fluxes from wildfire (Beche and others, 2005). Nutrient losses from burned watersheds result primarily from streamflow export in sediment which can transport relatively high levels of nutrients. Creating conditions that lower the risk of high intensity fires will also lower the risk of fire associated erosion, sedimentation, and nutrient transport to stream systems.

As explained in the Affected Environment of this SFEIS the TMDL listings include detailed water quality information in the "assessment record" via the DEQ website cited in the FEIS. The Hyalite Creek upper segment (MT41H003-132), which is on the Gallatin NF above the water intake, is listed for nutrients (chlorophyll-a, nitrogen, and phosphorous). The http://cwaic.mt.gov/Default.aspx website explains that Hyalite Creek does not violate water quality standards for these parameters but 2004 DEQ data shows that a comparison to reference reach condition indicates higher levels of these parameters than the reference reach. Subsequent Montana DEQ water quality monitoring (in 2006, 2008, and 2009) and field assessments have shown that the nutrient enrichment is due to Hyalite reservoir fluxuations and nutrient additions during the late summer and fall when the reservoir is low. The DEQ assessment discounted the "rangeland grazing, silviculture harvesting, and unpaved roads and trails" cause and considers the nutrient source to be Hyalite reservoir outflows (Schade, personal correspondence, 2010). Since the reasonable operation of dams was in existence as of 7/1/1971, reservoir fluxuations are considered "natural" sources of nutrient enrichment. Montana DEQ has indicated that the upper segment (MT41H003-132) is being evaluated for removal from the 303(d) list, in which case no nutrient TMDL would be required for Hyalite Creek. The Montana Code Annotated – 2007 75-5-703 section (10)(c) additionally specifies that "Pending completion of a TMDL on a water body listed pursuant to 75-5-303 new or expanded non-point source activities affecting a listed water-body may commence and continue if those activities are conducted in accordance with reasonable land, soil, and water conservation practices." Even though BMW project implementation related nutrient increases are not anticipated in Hyalite Creek, this provision would allow a small nutrient increase associated with the BMW project since "reasonable" BMP's are being planned and required.

Alternative 2 poses an increased potential for turbidity increases at the Bozeman Water Treatment Plant since the sediment increases would also result in some increase in turbidity. For Alternative 2 Hyalite Creek and Bozeman would meet the Category A 30% over natural sediment standard and would be in compliance with Montana Water quality standards and protect beneficial uses. Leverich Creek at an estimated 33.2% over natural would exceed the Gallatin NF sediment standards and would not comply with Montana Water quality standards.

The incremental effects of all BMW alternatives, including Alternative 2, on climate change and water resources is likely to be insignificant because of the very localized scale of treatments. These effects are very conjectural and do not provide a reasoned choice between alternatives. General patterns of overall climate change in the Northern Rockies emerge from multiple predictive models and are well documented. Some areas are likely to receive more precipitation and some less. Warming temperatures will result in less precipitation falling as snow, smaller snowpack, earlier snowmelt, increased incidence of rain-on-snow flooding, reduced dry-season streamflows, greater moisture stress on vegetation, and increased stress on aquatic ecosystems. Areas subject to increased climatic extremes are likely to experience more frequent and larger floods and more frequent and longer droughts. Warming conditions are likely to trigger more extensive and severe insect outbreaks and more frequent, larger, and more severe wildfires, contributing to reduced water quality through increased erosion. Clean water supplies will become increasingly scarce, and water-related ecosystem services will be at greater risk. Extensive climate change – water resource information is available at http://www.fs.fed.us/ccrc/topics/water.shtml and many other internet sources.

Wildfire growth potential and the probability of sediment increases similar to no action as displayed in the Bozeman Creek wildfire risk analysis (USFS, 2003) would likely be less than Alternative 1, particularly in the lower parts of Bozeman Creek and Hyalite Creek where many of the Alternative 2 fuel treatments are focused.

Cumulative Effects of Alternative 2

The R1R4 sediment modeling was run for Alternative 2 in a cumulative mode accounting for all existing roads, timber harvesting, and residential, and recreational developments in Bozeman, Hyalite, and Leverich Creeks. Timeframe for the cumulative effects analysis is 1980 to 2016. Overall sediment impacts of Alternative 2 would be increased over pre-project conditions due to an increase in road sediment from log hauling, thinning, and broadcast burn treatments. Sediment impacts would result in cumulative impacts with other sediment or nutrients impacting activities in Bozeman Creek, Hyalite Creek, or Leverich Creek which is primarily the existing roads and recreational activities.

The City of Bozeman thinning project cumulative impacts could be similar to Alternative 1 except that Bozeman Creek sediment could be elevated a total of 8.3% over natural if the City treatments were in the same time period as BMW.

The DNRC consideration of harvesting mountain pine beetle stands in the Bear Canyon area and the City of Bozeman's consideration of a municipal water storage impoundment in Bozeman Creek is the same as disclosed in the cumulative effects section for Alternative 1. Other activities' effects are described for alternative 2 and all of the alternatives in the BMW Cumulative Effects checklist which is located in the project record. In addition to the cumulative effects described above, cumulative effects are described for the Sourdough trailhead renovation, firewood cutting, minerals, fire suppression, weeds, facilities, recreation, land adjustments, and trail management. Most of these additional activities have no or very limited cumulative effects with BMW implementation.

Direct and Indirect Effects of Alternative 3

For Alternative 3, the R1R4 model was run assuming all temporary roads would be constructed in 2011, pre-commercial thinning done during 2011 and 2012, commercial thinning during 2011-2013, and prescribed burning from 2011 to 2013. It was also assumed that no wildfires would occur during 2010 – 2016 in order to display the potential sediment increases from Alternative 3 activities.

Table 39. Sediment yield estimates for Alternative 3.

Year	Natural Sediment (tons/year)	Road Sediment (tons/year)	Thinning Sediment (tons/year)	Broadcast Burn Sediment (tons/year)	Total Sediment (tons/year)	% Over Natural Sediment Delivery
Bozeman Creek at Water Intake near Forest Boundary						
2010	354	11.9	0	0	365.9	3.4
2011	354	15.3	4.7	1.8	375.8	6.1
2012	354	14.7	6.6	2.1	377.4	6.6
2013	354	14.3	7.4	2.2	377.9	6.8
2014	354	13.9	5.1	0.5	373.5	5.5
2015	354	12.6	3.4	0.1	369.8	4.5
2016	354	11.9	0	0	365.9	3.4
Hyalite Creek at Water Intake near Forest Boundary						
2010	533	30.7	0	0	563.7	5.8

Year	Natural Sediment (tons/year)	Road Sediment (tons/year)	Thinning Sediment (tons/year)	Broadcast Burn Sediment (tons/year)	Total Sediment (tons/year)	% Over Natural Sediment Delivery
2011	533	19.5	8.1	2.1	562.7	5.6
2012	533	19.5	12.0	2.5	567.0	6.4
2013	533	19.5	15.2	3.5	571.2	7.2
2014	533	19.5	7.4	0.7	560.6	5.2
2015	533	19.5	4.9	0	557.4	4.6
2016	533	19	0	0	552	3.6
Leverich Creek at Forest Boundary						
2008	29.8	2.5	0	0	32.3	8.4
2009	29.8	1.3	0	0	31.1	4.4
2010	29.8	1.3	0	0	31.1	4.4
2011	29.8	4.0	4.3	0	38.1	27.8
2012	29.8	2.9	6.1	0	40.2	34.9
2013	29.8	2.9	7.5	0	40.2	34.9
2014	29.8	2.9	4.7	0	37.4	25.5
2015	29.8	1.3	3.0	0	34.1	14.4
2016	29.8	1.3	0	0	32.7	4.4

Alternative 3 has the highest probability for sediment yield increases due to more temporary roads, pre-commercial thinning, and commercial thinning than the other alternatives.

Bozeman Creek sediment related to BMW would increase from an estimated 3.4% over natural in 2010 to 6.8 % in 2013, a 3.4% maximum increase. Hyalite Creek sediment would increase from an estimated 5.8% over natural in 2010 to a project maximum of 7.2% over natural in 2013and then decrease to 3.6% in 2016. The overall Hyalite Creek decrease in 2011 is due to the 2010 road decommissioning but the net increase in 2012 (after decommissioning) is about 2.6%. Alternative 3 sediment levels are projected to decrease to 3.6% over natural by 2016 when the sediment effects of BMW implementation would be substantially through. Leverich Creek sediment would decrease from an estimated 8.4% over natural in 2008 to 4.4% over natural in 2010 but increase to a maximum of 34.9 % over natural in 2011 and 2012, a 30.1% over natural maximum increase. Leverich Creek sediment reductions starting in 2009 are due to rehabilitation work completed in 2008 and 2009 (trail improvements and trail and road obliteration). In reality the implementation of the proposed treatments would likely be spread out over more than 3 years so the peak sediment increase would likely be less. In Bozeman Creek approximately 1.2 miles of temporary road would be constructed in part of sections 18, 19, and 20 T3S R5E as a spur of road 6219 to serve cable units 27A and 28C (FEIS pp. 2-6). This temporary road segment would cross a perennial stream tributary to Bozeman Creek in NE S19 T3S R5E. The potential road sediment increase is reflected in the road sediment column in Table 39. In Hyalite Creek 5.2 miles of temporary roads would be built in Alternative 3 but none of the temporary road locations cross intermittent or perennial streams so potential sediment increases in Hyalite Creek in Alternative 3 would result from thinning treatments and broadcast burning.

Leverich Creek, in Alternative 3 would be in excess of the Gallatin NF sediment standards and in fact the accelerated sediment levels in Alternatives 2 and 3 in Leverich Creek prompted development of alternatives 5 and 6 which reduced Leverich Creek sediment levels. Alternative 3 would reduce but not eliminate the potential for severe or extensive wildfires and associated potential for sharp sediment increases from precipitation events impacting burned areas.

Alternative 3 poses the highest increased potential for turbidity increases at the Bozeman Water Treatment Plant since the sediment increases would also result in some increase in turbidity. For Alternative 3, Bozeman Creek and Hyalite would meet the Category A 30% over natural sediment standard and would be in compliance with Montana Water quality standards. Leverich Creek would not comply with the Gallatin NF sediment standards or Montana water quality standards for Alternative 3.

Alternative 3 has higher potential for nutrient increases in Hyalite Creek from broadcast burning than Alternative 2 since more acres would be burned and the potential for nutrient increases into Hyalite Creek, although small, is greater than Alternative 2.

A water balance technique (ECA method) was run for Alternative 3 to calculate potential water yield increase assuming all mechanical harvesting and broadcast burns would act as clearcuts. The potential water yield increase for Alternative 3 would be an additional 265 acre feet of water yield in Bozeman Creek or 1.2% which combined with the approximately current increase of 1% would result in an increase of 2.2%. Hyalite Creek increase would be an additional 203 acre feet or an increase of 0.4% which combined with the current increase of 1.8% would result in total water yield increase of 2.2%. This is much too low of a potential change to be measurable or result in low flow reductions. In actuality the partial canopy reduction methods being proposed will result in only an estimated 10-20% of clearcut water yield increase but a slightly earlier snowmelt in the thinned units due to the more open canopy.

Cumulative Effects of Alternative 3

The R1R4 sediment modeling was run for Alternative 3 in a cumulative mode accounting for all existing roads, timber harvesting, and residential, and recreational developments in Bozeman, Hyalite, and Leverich Creeks. Timeframe for the cumulative effects analysis is 1980 to 2016. Overall sediment impacts of Alternative 3 would be increased over pre-project conditions due to an increase in temporary roads, thinning, and broadcast burn treatments. Sediment impacts would result in cumulative impacts with other sediment impacting activities in Bozeman Creek, Hyalite Creek, or Leverich Creek, which are primarily the existing roads and recreational activities. The cumulative sediment effects for Alternative 3 would be in compliance with sediment standards for Bozeman Creek and Hyalite Creek and in exceedence for Leverich Creek.

The City of Bozeman thinning project cumulative impacts could be similar to Alternative 1 except that Bozeman Creek sediment could be elevated to a total of 9.3% over natural if the City treatments were in the same time period as BMW.

The DNRC consideration to harvest mountain pine beetle stands in the Bear Canyon area and the City of Bozeman's potential for a municipal water storage impoundment in Bozeman Creek are the same as disclosed in the cumulative effects section for Alternative 1.

Other activities' cumulative effects are described for alternative 3 and all of the alternatives in the BMW Cumulative Effects checklist which is located in the project record. In addition to the cumulative effects described above, cumulative effects are described for the Sourdough trailhead renovation, firewood cutting, minerals, fire suppression, weeds, facilities, recreation, land adjustments, and trail management. Most of these additional activities have no or very limited cumulative effects with BMW implementation.

Direct and Indirect Effects of Alternative 4

For Alternative 4, the R1R4 model was run assuming pre-commercial thinning done during 2011 and 2012, commercial thinning during 2011-2013, and prescribed burning from 2011 to 2013. It was also assumed that no wildfires would occur during 2010 – 2016 in order to display the potential sediment increases from Alternative 4 activities.

Alternative 4 has a reduced probability for sediment yield compared to alternatives 2 and 3 because the only fuel reduction treatments in this alternative are broadcast burning and thinning of small diameter trees. No temporary roads would be constructed.

In Alternative 4, Bozeman Creek sediment related to BMW would increase from an estimated 3.4% over natural in 2010 to 5.3% in 2011, a 1.7% maximum increase. Hyalite Creek sediment would decrease from an estimated 5.8% over natural in 2010 to a project maximum of 4.7% over natural in 2012. The overall Hyalite Creek decrease is due to the 2010 road decommissioning and the net increase (after decommissioning) is about 1.1%. Alternative 4 sediment levels are projected to decrease to 3.6% over natural by 2016 when the effects of BMW implementation would be through. Leverich Creek sediment would decrease from an estimated 8.4% over natural in 2008 to 4.4% over natural in 2010 but increase to a maximum of 9.7 % over natural in 2013, a 5.3% over natural maximum increase. In reality the implementation of the proposed treatments would likely be spread out over more than 3 years so the peak sediment increase would likely be less. Leverich Creek sediment reductions starting in 2009 are due to rehabilitation work completed in 2008 and 2009 (trail improvements and trail and road obliteration).

Table 40. Sediment yield estimates for Alternative 4.

Year	Natural Sediment (tons/year)	Road Sediment (tons/year)	Thinning Sediment (tons/year)	Broadcast Burn Sediment (tons/year)	Total Sediment (tons/year)	% Over Natural Sediment Delivery
Bozeman Creek at Water Intake near Forest Boundary						
2010	354	11.9	0	0	365.9	3.4
2011	354	12.6	0.3	4.3	371.2	4.9
2012	354	12.6	0.4	5.2	372.2	5.1
2013	354	12.6	0.2	5.4	372.9	5.3
2014	354	12.6	0.2	1.2	368.7	4.1
2015	354	12.6	0.1	0.2	367.6	3.8
2016	354	11.9	0	0	365.9	3.4
Hyalite Creek at Water Intake near Forest Boundary						
2010	533	30.7	0	0	563.7	5.8
2011	533	19.5	2.0	3.6	558.1	4.7
2012	533	19.5	1.0	4.4	557.9	4.7
2013	533	19.5	1.0	4.5	558.0	4.7
2014	533	19.5	0.5	4.5	557.5	4.6
2015	533	19.5	0.1	1.0	553.6	3.9
2016	533	19	0	0	552	3.6
Leverich Creek at Forest Boundary						
2008	29.8	2.5	0	0	32.3	8.4
2009	29.8	1.3	0	0	31.1	4.4
2010	29.8	1.3	0	0	31.1	4.4
2011	29.8	1.3	0	1.3	32.4	8.7
2012	29.8	1.3	0	1.5	32.6	9.4
2013	29.8	1.3	0	1.6	32.7	9.7
2014	29.8	1.3	0	0.3	31.4	5.4
2015	29.8	1.3	0	0.1	31.2	4.7
2016	29.8	1.3	0	0	31.1	4.4

Alternative 4 poses a potential for short term turbidity increases at the Bozeman Water Treatment Plant since the sediment increases would also result in some increase in turbidity. For Alternative 4, Hyalite Creek, Bozeman Creek, and Leverich Creek would be in compliance with Gallatin NF Category A 30% over natural sediment standard and would be in compliance with Montana Water quality standards.

A concern with the prescribed broadcast burns is the potential for nutrient enrichment of Hyalite Creek since it is included on the TMDL list for phosphorous and nitrogen. Conversion of organic vegetation to inorganic nutrients and reduced plant uptake after fires can result in increased leaching of nutrients to streams. Nutrient increases in streamflows have been measured in several research watersheds from wildfires – usually most prominently immediately after the wildfire event. The understory and pile burns in the Bozeman Municipal watershed project have considerably less biomass consumption and burning depth than wildfires. Alternative 4, however, has the highest potential for nutrient increases in Hyalite Creek from broadcast burning than any of the alternatives since units 16, 17, 18, 19, 21, 22, 23, and 35 in the Hyalite Creek drainage would have fuel reduction understory burns. Per the discussion of nutrient release from broadcast burns in Alternative 2, nutrient releases would be expected to be limited by buffering (50') from perennial streams and would not be expected to have measurable nutrient effects. Measurable nutrient effects however could occur from wildfires.

A water balance technique (ECA method) was run for Alternative 4 to calculate potential water yield increase assuming all mechanical harvesting and broadcast burns would act as clearcuts. The potential water yield increase for Alternative 4 would be an additional 322 acre feet of water yield in Bozeman Creek or 1.5% which combined with the approximately current increase of 1% would result in an increase of 2.5%. Hyalite Creek increase would be an additional 274 acre feet or an increase of 0.6% which combined with the current increase of 1.8% would result in total water yield increase of 2.4%. This is much too low of a potential change to be measurable or result in low flow reductions. In actuality the partial canopy reduction methods being proposed will result in only an estimated 10-20% of clear-cut water yield increase but a slightly earlier snowmelt in the thinned units due to the more open canopy.

Cumulative Effects of Alternative 4

The R1R4 sediment modeling was run for Alternative 4 in a cumulative mode accounting for all existing roads, timber harvesting, and residential, and recreational developments in Bozeman, Hyalite, and Leverich Creeks. Timeframe for the cumulative effects analysis is 1980 to 2016. Overall sediment impacts of Alternative 4 would be increased over pre-project conditions due to thinning, and broadcast burn treatments. Sediment impacts would result in cumulative impacts with other sediment impacting activities in Bozeman Creek, Hyalite Creek, or Leverich Creek, which are primarily the existing roads and recreational activities. The cumulative sediment effects for Alternative 4 would be in compliance with sediment standards for Bozeman Creek, Hyalite Creek and Leverich Creek.

The City of Bozeman's thinning project cumulative impacts could be similar to Alternative 1 except that Bozeman Creek sediment could be elevated to a total of 7.6% over natural if the City treatments were in the same time period as BMW.

The DNRC consideration to harvest mountain pine beetle stands in the Bear Canyon area and the City of Bozeman's potential for a municipal water storage impoundment in

Bozeman Creek are the same as disclosed in the cumulative effects section for Alternative 1.

Other activities' cumulative effects are described for alternative 4 and all of the alternatives in the BMW Cumulative Effects checklist which is located in the project record. In addition to the cumulative effects described above, cumulative effects are described for the Sourdough trailhead renovation, firewood cutting, minerals, fire suppression, weeds, facilities, recreation, land adjustments, and trail management. Most of these additional activities have no or very limited cumulative effects with BMW implementation.

Direct and Indirect Effects of Alternative 5

For Alternative 5, the R1R4 model was run assuming all temporary roads would be constructed in 2011, pre-commercial thinning done during 2011 and 2012, commercial thinning during 2011-2013, and prescribed burning from 2011 to 2013. It was also assumed that no wildfires would occur during 2010 – 2016 in order to display the potential sediment increases from Alternative 5 activities. Alternative 5 has reduced probability from Alternative 3, for sediment yield increases due to fewer temporary roads, less thinning with cable systems, change of several units to helicopter harvesting, and reduction of sediment generation activities particularly in Leverich Canyon. Projected Alternative 5 sediment levels, however, are more than Alternatives 1 and 4.

For Alternative 5, Bozeman Creek sediment related to BMW would increase from an estimated 3.4% over natural in 2010 to 6.0% in 2013, a 2.6% maximum increase. Hyalite Creek sediment would decrease from an estimated 5.8% over natural in 2010 to a project maximum of 5.6% over natural in 2013. The overall Hyalite Creek decrease in 2011 is due to the 2010 road decommissioning but the net increase in 2012 (after decommissioning) is about 2.0%. Alternative 5 sediment levels are projected to decrease to 3.6% over natural by 2016 when the sediment effects of BMW implementation would be substantially through. Leverich Creek sediment would decrease from an estimated 8.4% over natural in 2008 to

Table 41. Sediment yield estimates for Alternative 5.

Year	Natural Sediment (tons/year)	Road Sediment (tons/year)	Thinning Sediment (tons/year)	Broadcast Burn Sediment (tons/year)	Total Sediment (tons/year)	% Over Natural Sediment Delivery
Bozeman Creek at Water Intake near Forest Boundary						
2010	354	11.9	0	0	365.9	3.4
2011	354	12.6	3.9	1.8	372.3	5.2
2012	354	12.6	5.3	2.1	374.0	5.6
2013	354	12.6	6.6	2.2	375.4	6.0
2014	354	12.6	4.1	0.5	371.2	4.9
2015	354	12.6	2.8	0.1	369.5	4.4

Year	Natural Sediment (tons/year)	Road Sediment (tons/year)	Thinning Sediment (tons/year)	Broadcast Burn Sediment (tons/year)	Total Sediment (tons/year)	% Over Natural Sediment Delivery
2016	354	11.9	0	0	365.9	3.4
Hyalite Creek at Water Intake near Forest Boundary						
2010	533	30.7	0	0	563.4	5.8
2011	533	19.5	5.5	0	558	4.7
2012	533	19.5	8.2	0	560.7	5.2
2013	533	19.5	10.3	0	562.8	5.6
2014	533	19.5	6.4	0	559	4.9
2015	533	19.5	4.2	0	556.7	4.4
2016	533	19	0	0	552	3.6
Leverich Creek at Forest Boundary						
2008	29.8	2.5	0	0	32.3	8.4
2009	29.8	1.3	0	0	31.1	4.4
2010	29.8	1.3	0	0	31.1	4.4
2011	29.8	2.0	1.3	0	33.1	11.1
2012	29.8	2.0	1.6	0	33.4	12.0
2013	29.8	1.3	1.0	0	32.1	7.8
2014	29.8	1.3	0.6	0	31.7	6.4
2016	29.8	1.3	0.1	0	31.2	4.7
2016	29.8	1.3	0	0	31.1	4.4

4.4% over natural in 2010 but increase to a maximum of 12% over natural in 2012, a 7.6% over natural maximum increase. Leverich Creek sediment reductions starting in 2009 are due to rehabilitation work completed in 2008 and 2009 (trail improvements and trail and road obliteration). In reality implementation of the proposed treatments would likely be spread out over more than 3 years so the peak sediment increase would likely be less. In Hyalite Creek about 2.7 miles of temporary roads would be built in Alternative 5 but none of the temporary road locations cross intermittent or perennial streams so potential sediment increases in Hyalite Creek in Alternative 5 would result from thinning treatments and broadcast burning.

Leverich Creek, in Alternative 5, would comply with the Gallatin NF sediment standards and in fact the accelerated sediment levels in Alternatives 2 and 3 in Leverich Creek prompted development of Alternatives 5 and 6 which reduced Leverich Creek sediment levels. Alternative 5 would reduce but not eliminate the potential for risk of severe or extensive wildfire and associated potential for sharp sediment increases from precipitation events impacting burned areas.

Alternative 5 poses potential for turbidity increases at the Bozeman Water Treatment Plant since the sediment increases would also result in some increase in turbidity. Bozeman, Hyalite, and Leverich Creeks, would meet the Category A 30% over natural sediment standard and would be in compliance with Montana Water quality standards.

Alternative 5 has no potential for nutrient increases in Hyalite Creek from broadcast burning since none of the treatment units in the Hyalite drainage would include broadcast burning.

A water balance technique (ECA method) was run for Alternative 5 to calculate potential water yield increase assuming all mechanical harvesting and broadcast burns would act as clearcuts. The potential water yield increase for Alternative 5 would be an additional 274 acre feet of water yield in Bozeman Creek or 1.2% which combined with the approximately current increase of 1% would result in an increase of 2.2%. Hyalite Creek increase would be an additional 203 acre feet or an increase of 0.3% which combined with the current increase of 1.8% would result in total water yield increase of 2.1%. This is much too low of a potential change to be measurable or result in low flow reductions. In actuality the partial canopy reduction methods being proposed will result in only an estimated 10-20% of clearcut water yield increase but a slightly earlier snowmelt in the thinned units due to the more open canopy.

Alternative 5 poses lower sediment increase potential than Alternatives 2 and 3 for Hyalite Creek and Leverich Creek, and Alternative 3 for Bozeman Creek. For Alternative 5, Bozeman Creek, Hyalite Creek, and Leverich Creek would meet the Category A 30% over natural sediment standard and would be in compliance with Montana Water quality standards.

Cumulative Effects of Alternative 5

The R1R4 sediment modeling was run for Alternative 5 in a cumulative mode accounting for all existing roads, timber harvesting, and residential, and recreational developments in Bozeman, Hyalite, and Leverich Creeks. Timeframe for the cumulative effects analysis is 1980 to 2016. Overall sediment impacts of Alternative 5 would be increased over pre-project conditions due to thinning and broadcast burn treatments. Sediment impacts would result in cumulative impacts with other sediment impacting activities in Bozeman Creek, Hyalite Creek, or Leverich Creek, which are primarily the existing roads and recreational activities. The cumulative sediment effects for Alternative 5 would be in compliance with sediment standards for Bozeman, Hyalite and Leverich Creeks.

The City of Bozeman thinning project cumulative impacts could be similar to Alternative 1 except that Bozeman Creek sediment could be elevated a total of 8.2% over natural if the City treatments were in the same time period as BMW.

The DNRC consideration to harvest mountain pine beetle stands in the Bear Canyon area and the City of Bozeman's potential for a municipal water storage impoundment in Bozeman Creek are the same as disclosed in the cumulative effects section for Alternative 1.

Other activities' cumulative effects are described for alternative 5 and all of the alternatives in the BMW Cumulative Effects checklist which is located in the project record. In addition to the cumulative effects described above, cumulative effects are described for the Sourdough trailhead renovation, firewood cutting, minerals, fire suppression, weeds, facilities, recreation, land adjustments, and trail management. Most of these additional activities have no or very limited cumulative effects with BMW implementation.

Direct and Indirect Effects of Alternative 6

Alternative 6 has further reduced probability for sediment yield compared to Alternative 5 due to fewer temporary roads, less thinning with cable systems, and further reduction of sediment generation activities particularly in Hyalite Creek and Leverich Canyon. For Alternative 6, the R1R4 model was run assuming all temporary roads would be constructed in 2011, pre-commercial thinning done during 2011 and 2012, commercial thinning during 2011-2013, and prescribed burning from 2011 to 2013. Alternative 6 was modeled assuming the recommended 100' no ignition buffer zone from perennial streams as applied to both Hyalite and Bozeman Creeks. If a 50' no ignition buffer was used, the Bozeman Creek broadcast burn sediment would be about 0.8 tons/ year greater (0.2% over natural) and for Hyalite Creek about 0.1 tons year greater (0.02 over natural). It was also assumed that no wildfires would occur during 2010 – 2016.

Table 42. Sediment yield estimates for Alternative 6.

Year	Natural Sediment (tons/year)	Road Sediment (tons/year)	Thinning Sediment (tons/year)	Broadcast Burn Sediment (tons/year)	Total Sediment (tons/year)	% Over Natural Sediment Delivery
Bozeman Creek at Water Intake near Forest Boundary						
2010	354	11.9	0	0	365.9	3.4
2011	354	12.6	1.4	1.2	369.2	4.3
2012	354	12.6	2.1	1.4	370.1	4.5
2013	354	12.6	2.5	1.5	370.6	4.7
2014	354	12.6	1.5	0.3	368.4	4.1
2015	354	12.6	1.0	0.1	367.7	3.9
2016	354	11.9	0	0	365.9	3.4
Hyalite Creek at Water Intake near Forest Boundary						
2010	533	30.7	0	0	563.4	5.8
2011	533	19.5	2.7	0.15	555.3	4.2
2012	533	19.5	3.8	0.15	556.5	4.3

Year	Natural Sediment (tons/year)	Road Sediment (tons/year)	Thinning Sediment (tons/year)	Broadcast Burn Sediment (tons/year)	Total Sediment (tons/year)	% Over Natural Sediment Delivery
2013	533	19.5	4.7	0.2	557.4	4.6
2014	533	19.5	3.0	0.05	559	4.9
2015	533	19.5	1.9	0	554.4	4.0
2016	533	19	0	0	552	3.6
Leverich Creek at Forest Boundary						
2008	29.8	2.5	0	0	32.3	8.4
2009	29.8	1.3	0	0	31.1	4.4
2010	29.8	1.3	0	0	31.1	4.4
2011	29.8	1.3	0.4	0	31.5	5.7
2012	29.8	1.3	0.2	0	31.3	5.0
2013	29.8	1.3	0.1	0	31.2	4.7
2014	29.8	1.3	0.1	0	31.4	4.7
2015	29.8	1.3	0	0	31.1	4.4
2016	29.8	1.3	0	0	31.1	4.4

Alternative 6 sediment levels are lower than Alternative 5 due primarily to fewer treated acres. Bozeman Creek sediment would increase from an estimated 3.4% over natural in 2008 to 4.5% in 2011, a 1.1 % maximum increase. Hyalite Creek sediment would decrease from an estimated 5.8% over natural in 2010 to a project maximum of 4.9% over natural in 2014. The overall Hyalite Creek decrease in 2011 is due to the 2010 road decommissioning and improved open road drainage, but the net increase in 2014 (after 2010 decommissioning) is about 1.3% over natural. Alternative 6 sediment levels in Hyalite Creek are projected to decrease to 3.6% over natural by 2016 when the sediment effects of BMW implementation would be substantially over. The road decommissioning and trail rehabilitation work in Leverich Creek, which occurred in 2008 and 2009, and the associated sediment reduction (4.0 tons/year) would more than offset the thinning sediment (maximum of 0.4 tons/year in 2011). Although the sediment standards for the Gallatin NF for Bozeman and Hyalite Creeks are 30% over natural, Alternative 6 was constrained to keep sediment levels in Hyalite Creek at a maximum of 5% over natural and Bozeman Creek at 5% over natural to reduce potential turbidity impacts and operational problems at the Bozeman Water Treatment Plant. In reality the implementation of the proposed treatments would be spread out over more than 3 years so the peak sediment increase would likely be less. In Bozeman Creek no temporary roads would be built above the water intakes so potential sediment increases would result primarily from thinning treatments and broadcast burning. In Hyalite Creek about 2.1 miles of temporary roads would be built in Alternative 6. All temporary road locations in Alternative 6 were examined on 8/10 and 9/10 with no crossings of intermittent or perennial streams and no temporary road sediment increase potential. In Leverich Creek a potential temporary road segment in Alternative 6 is not located near stream channels (on the divide between Leverich and Bozeman Creeks) but would be filtered via slash filter windrows as specified in the mitigation measures. The overall Leverich Creek sediment yield decrease through the implementation of the project (8.4 % to 4.4% in 2010, increasing to 5.7% in 2011 from fuels treatments, then declining to 4.4% by 2015) is due to the sediment reductions from the road and trail rehabilitation in 2008 and 2009.

Treatment units and associated activities within the Hodgeman Canyon and Cottonwood Creek watersheds were not modeled for sediment since proposed treatment units within the Cottonwood Creek watershed are located on the hydrologic divide separating the Cottonwood and Hyalite Creek drainages. Likelihood of direct, indirect and cumulative effects sediment yields is low. Proposed treatment units within the Hodgeman Canyon watershed have very limited potential for sediment increase and are located above several ditches which do not connect to either Hyalite or Bozeman Creeks. Temporary road locations in units 16A, 16C, and 39 on the Hyalite/South Cottonwood Creek divide and in units 13C and 38 in Hodgeman Canyon were examined for potential stream crossings. None of the temporary road locations cross intermittent or perennial stream channels which could result in sediment conveyance.

Alternative 6 poses lower sediment increase potential than all other alternatives except for the no action Alternative 1 for Bozeman Creek, Hyalite Creek, and Leverich Creek. For Alternative 6, Bozeman Creek, Hyalite Creek, and Leverich Creek would meet the Category A 30% over natural sediment standard and would be in compliance with Montana Water quality standards.

Additional sediment modeling was completed for BMW Alternative 6 to estimate reduced sediment levels in both Bozeman Creek and Hyalite Creek assuming robust wildfires occur after Alternative 6 was fully implemented. The analysis would be fairly similar for Alternatives 2-6. The analysis was based on FARSITE simulations for wildfires of 1000, 2000, and 4000 acres for Bozeman Creek and Hyalite Creek. The acreages for additional analysis were based on the FARSITE simulation discussed on page 3-10 of the BMW FEIS for the 85th and 97th percentile weather and three ignition points. Resulting fire sizes modeled were then based on Table 2.2 (BMW FEIS p. 2-29) and designed to cover a wide range of fire sizes in each watershed.

The BMW sediment % > natural is the same as shown in Table 43 for “BMW not implemented”. The “BMW implemented” rows assume that the BMW treated acres are totally within the wildfire area so the reduced %>natural figures are probably an over estimation of potential sediment reduction since the wildfires could burn areas outside of BMW treatment boundaries and not all areas within BMW treatment areas would be subjected to wildfire. As the size of wildfires declines (4000 to 1000 acres) the wildfire locations from FARSITE runs have a higher percentage of area within BMW treatment units hence the relative sediment reduction effectiveness increases. The BMW project, if fully implemented, could result in a modest reduction in sediment yields from a moderate to large size wildfire compared to BMW not implemented. Since the sediment standard is 30% over natural for each drainage the resulting sediment yields would still exceed the sediment standard for Bozeman Creek for wildfires larger than 1000 acres and more than 2000 acres in Hyalite Creek. For smaller fires (1000 to 2000 acres) and primarily within the BMW treated areas, the % of sediment reductions would be greater.

Table 43. A comparison of estimated sediment increase from wildfire with treatment and without treatment in the Bozeman Creek and Hyalite Creek drainages.

Bozeman Creek	**Sediment %>natural**	**Hyalite Creek**	**Sediment %>natural**
no action - no wildfires	3.4	no action - no wildfires	3.6
Alternative 6 - no wildfires	4.7	Alternative 6 - no wildfires	4.6
14,720 acre wildfire - BMW not implemented	357	16,000 acre wildfire - BMW not implemented	160
14,720 acre wildfire - BMW implemented	315	16,000 acre wildfire - BMW implemented	115
6,400 acre wildfire - BMW not implemented	161	10,000 acre wildfire - BMW not implemented	102
6,400 acre wildfire - BMW implemented	118	10,000 acre wildfire - BMW implemented	87
4,000 acre wildfire - BMW not implemented	105	4,000 acre wildfire - BMW not implemented	56
4,000 acre wildfire - BMW implemented	54	4,000 acre wildfire - BMW implemented	30
2,000 acre wildfire - BMW not implemented	57	2,000 acre wildfire - BMW not implemented	31
2,000 acre wildfire - BMW implemented	32	2,000 acre wildfire - BMW implemented	18
1,000 acre wildfire - BMW not implemented	34	1,000 acre wildfire - BMW not implemented	19
1,000 acre wildfire - BMW implemented	21	1,000 acre wildfire - BMW implemented	12

Potential for burn nutrient enrichment in Hyalite Creek from broadcast burning is discussed in detail in the Affected Environment and for Alternative 2. Alternative 6 includes 2 broadcast burn units above the City of Bozeman water intake in Hyalite

Creek. Unit 19 shown in Figures 16 and 17 is located about 1 mile west of Langohr Campground and was examined for potential nutrient effects on September 13, 2010.

Figure 16. Shows unit 19 in Hyalite Creek, which is proposed for an understory broadcast burn.

Figure 17. Shows the ephemeral draw/"swale" that unit 19 would drain into. The ephemeral draw/"swale" has no stream channels (perennial or intermittent) and no surface hydrologic connectivity to Hyalite Creek for nutrient discharges.

Figure 18. This photo shows unit 22C. The photo was taken on 9/17/2010.

Unit 22C has 2 small perennial streams which discharge into Hyalite Creek via ditch relief culverts. The streams had perennial flow on 9/17/10 augmented by several inches of rain in the preceding 3 weeks. The channel is heavily vegetated with extensive sediment filtration. Unit 22C has a small potential for nutrient and sediment release to Hyalite Creek from the broadcast burn (Table 42) so for Alternative 6 specific buffering of 100’ from perennial streams in unit 22C was recommended in mitigation measures for all BMW stream broadcast burns in Bozeman Creek and Hyalite Creeks.

Potential nutrient discharge into Hyalite and Bozeman Creeks in Alternative 6 is negligible and is the lowest in all of the action alternatives except for Alternative 5 which has no broadcast burn units in Hyalite Creek.

A water balance technique (ECA method) was run for Alternative 6 to calculate potential water yield increase. It was assumed that all mechanical harvesting and broadcast burns would act as clearcuts. The potential water yield increase for Alternative 6 would be an additional 274 acre feet of water yield in Bozeman Creek or 1.1% which combined with the approximately current increase of 1% over natural would result in a total increase of 2.1%. Hyalite Creek increase would be an additional 139 acre feet or an increase of 0.2% which combined with the current increase of 1.8% would result in total water yield increase of 2.0%. This is much too low of a potential change to be measurable or result in low flow reductions. In actuality the partial canopy reduction methods being proposed will result in only an estimated 10-20% of clearcut water yield increase but a slightly earlier snowmelt in the thinned units due to the more open canopy.

Climate change effects for Alternative 6, and stormwater permit analysis is discussed in detail in the effects section for Alternative 2.

Cumulative Effects of Alternative 6

The R1R4 sediment modeling was run for Alternative 6 in a cumulative mode accounting for all existing roads, timber harvesting, and residential, and recreational developments in Bozeman, Hyalite, and Leverich Creeks. Timeframe for the cumulative effects analysis is 1980 to 2016. Overall sediment impacts of Alternative 6 would be increased over pre-project conditions due to an increase in temporary roads, thinning, and broadcast burn treatments. Sediment impacts would result in cumulative impacts with other sediment impacting activities in Bozeman Creek, Hyalite Creek, or Leverich Creek which is primarily the existing roads and recreational activities. The cumulative sediment effects for Alternative 6 would be in compliance with the sediment standard for Bozeman Creek, Hyalite Creek, and Leverich Creek.

The City of Bozeman’s thinning project cumulative impacts could be similar to Alternative 1 except that Bozeman Creek sediment could be elevated to a total of 7.5% over natural if the City treatments were in the same time period as BMW.

The DNRC consideration to harvest mountain pile beetle stands in the Bear Canyon area and the City of Bozeman’s potential for a municipal water storage impoundment in Bozeman Creek are the same as disclosed in the cumulative effects section for Alternative 1.

Other activities’ cumulative effects are described for Alternative 6 and all of the alternatives in the BMW Cumulative Effects checklist which is located in the project record. In addition to the cumulative effects described above, cumulative effects are described for the Sourdough trailhead renovation, firewood cutting, minerals, fire suppression, weeds, facilities, recreation, land adjustments, and trail management. Most of these additional activities have no or very limited cumulative effects with BMW implementation.

Design Features and Mitigation Incorporated in Action Alternatives for Resource Protection

In the effects analysis, sediment delivery modeling takes into consideration the benefits of the following design features for the identified alternatives. These recommended design features have been incorporated into the alternatives (FEIS, 2-16, B 12-14; SFEIS, Appendix A).

Retain a no ignition buffer of at least 50’ for burn treatment areas adjacent to Bozeman Creek, Hyalite Creek, and perennial tributaries (Alternatives 2-6).

Apply standard BT timber sale protection clauses to the commercial harvest activities to protect against soil erosion and sedimentation. Include standard BMP’s for all activities including Montana SMZ compliance rules.

Apply BMP's for Forestry in Montana (MDNRC, 2006). These are incorporated into the SFEIS Appendix A.

A slash filter windrow would be installed below temporary road B-50, within the Leverich drainage, as needed. This mitigation affects about ¼ mile of road and is limited to the areas where soil movement could be directed to any water. The Forest Hydrologist would identify the areas of concern (Alternatives 5 and 6).

The Gallatin Forest Plan, Forest Wide Standards 10.2 (page II-23) requires that Best Management Practices (BMP's) will be used in all Forest watersheds. The Montana Forestry BMP's are included in Appendix A of the SFEIS which is required to be followed in all timber harvest and road construction activities. Forest Plan Direction A.5 (page II-1) requires the Gallatin NF to meet or exceed State of Montana water quality standards.

Monitoring and Monitoring Requirements

<u>Water Quality/BMP's</u>

At least 1 BMP review will be conducted for some of the thinning and prescribed burn units as well as for some the temporary road segments. The BMP review team will use the Montana BMP audit forms augmented by the additional BMP's and project specific mitigation for the Bozeman Municipal Watershed Project. The objective of the BMP review is to document BMP and SMZ rule compliance and to validate the erosion and water quality effects predicted by examining soil erosion, runoff and water quality response, and re-vegetation of prescribed burns. A BMP review report, including observations and recommendations, will be prepared by the Gallatin NF Hydrologist and submitted to the Bozeman District Ranger.

Additional Mitigation and Monitoring is recommended based on the most recent coordination efforts: These practices were not incorporated in alternative 6, as analyzed because the project complies with all applicable laws and regulation with or without the increased no ignition buffer. The effects analysis discusses impacts to water quality with and without the expanded buffer. The additional monitoring does not alter analysis.

Retain a no ignition buffer of at least 100' for burn treatment areas adjacent to Bozeman Creek, Hyalite Creek, and perennial tributaries (Alternative 6).

Water Quality Monitoring

At least 1 BMP field implementation monitoring review will be conducted during the BMW project to review the implementation of mitigation measures and BMP's, compliance with project and Forest Plan goals-objectives-standards, and compliance with BMW BMP's. This implementation review process has been used on the Gallatin NF since 2005 to review a wide variety of projects and document conclusions and recommendations relevant to future projects – several of which are cited in this SFEIS. The BMP review team will use the Montana BMP audit forms augmented by the additional BMP's and EIS required mitigation for the Bozeman Municipal Watershed Project. The objective of the BMP review is to document BMP and SMZ rule compliance and to validate the erosion and water quality effects predicted by examination of soil erosion, runoff and water quality response, and re-vegetation of broadcast burns. An implementation monitoring BMP review report, including observations and recommendations, will be prepared by the Gallatin NF Hydrologist and submitted to the Bozeman District Ranger and posted on the Gallatin NF intranet (internal) and internet (external) for public access.

The Gallatin National Forest will be working cooperatively with the City of Bozeman water treatment plant in monitoring water quality at the water intakes – particularly for turbidity. The water intakes at Hyalite Creek and Bozeman Creek are monitored continuously for turbidity using HACH Surface Scatter 6 turbidity meters for each drainage. After mixing intake source water the turbidity is then measured with a HACH 1720C turbidity meter with multiple turbidity measurements through treatment plant processing. Final treatment plant water turbidity is measured with HACH 1720E turbidity meters. An important monitoring process is to measure turbidity after filtration at each of the 12 filtration units. Occasionally elevated turbidity spikes are recorded in either Hyalite or Bozeman Creek which are most commonly traced to a section of stream bank failure in Bozeman Creek or snowmelt or thunderstorm rain events in Lick Creek (tributary of Hyalite Creek). Turbidity records indicate that snowmelt runoff (usually late April to early June) is the most common time period of turbidity increase but the highest turbidity readings are usually associated with a July or August localized intensive thunderstorm. Incoming turbidity is usually very clear – in the 1-3 NTU range with snowmelt elevations to the 10-25 NTU range occasional summer thunderstorm related spikes in the 100 NTU range. Outgoing treatment plant turbidity is usually less than 0.1 NTU and well within the required water treatment "effluent" turbidity standards (0.3 NTU). The Treatment Plant is required to maintain extensive records of turbidity and multiple other water quality chemical parameters with monthly reports submitted to the Montana DEQ (required for municipal water treatment plants). The new City of Bozeman Water Treatment Plant turbidity monitoring is anticipated to be at least as intensive. The continuous monitoring of incoming turbidity is essential for the water treatment operations to apply appropriate levels of flocculants in the treatment process. During the BMW project turbidity spikes will be traced to the watershed source and if appropriate mitigation taken to reduce the turbidity source if related to BMW implementation.

Compliance with Applicable Water Quality Laws, Regulation, and Forest Plan Guidance

Applicable water quality laws, regulations, and Forest Plan Guidance are detailed in the Affected Environment section. Alternative 6 meets all applicable water quality laws, regulations and Forest Plan Guidance for Bozeman Creek and Hyalite Creek. Leverich Creek complies for Alternatives 1, 4, 5, and 6 but not for Alternatives 2 and 3 due to exceedence of Gallatin NF sediment standards. Hyalite Creek currently meets Montana A-1 Classification standards and Bozeman Creek meets Montana A-Closed standards within the BMW project area. The BMW project would comply with Hyalite Creek and Bozeman Creek Clean Water Act standards. The Montana DEQ 2008 and 2010 303(d) and TMDL preparation process and status are also disclosed in detail in the Affected Environment section.

Projected sediment level increases in Alternative 6 have been further mitigated to be very low and not readily measurable with conventional sediment measurement equipment. The maximum increase in Bozeman Creek sediment of 1.3% with maximum total increase of 4.7% over natural, maximum increase in Hyalite Creek, of 1.4% with maximum total increase of 4.9% over natural, and maximum increase in Leverich Creek, of 1.3% with maximum total increase of 5.7% over natural are well within compliance with the Gallatin NF 30% over natural standard for municipal watersheds or sensitive streams.

The BMP's included in this BMW SFEIS were based on the Montana Forestry BMP's, which form the nucleus of the Montana BMP audits, augmented by more stringent SMZ guidelines used on the Gallatin NF due to Trout Unlimited Settlement Agreement provisions. The Trout Unlimited settlement agreement is discussed in the fisheries section of this SFEIS. In addition multiple GNF BMP reviews of fuel treatment projects and timber sales/roads were used to refine the BMP's for BMW. All reasonable BMP's have been incorporated into the project design. The use of haul roads and associated sediment change is described in the SFEIS in the sediment modeling methodology and displayed for each alternative. The sediment modeling used road mileage and use (traveled, closed, etc.) for appropriate sediment coefficients. The BMW project has very limited dirt road haul distance as most of the haul route is on the paved Hyalite Canyon road. Road decommissioning and extensive BMP improvements in Hyalite Creek drainage in 2010 have reduced sediment levels from 5.8% over natural in Hyalite Creek to 4.4% over natural. In the preferred Alternative 6 sediment modeling indicates a maximum of 4.9% over natural resulting in an overall reduced sediment level of 0.9% compared pre-project conditions. Additional Alternative 6 mitigation of slash filter windrows in Leverich Creek and a recommended extension of perennial stream buffers of 100' for broadcast burns in both Hyalite and Bozeman further reduce potential for sediment and nutrient increases. Both 50 foot and 100 foot buffer distances are effective at minimizing sediment and nutrient increases but 100 foot is slightly more effective.

The Gallatin sediment standards were revised during the Travel Plan process (in cooperation with the Montana DEQ) to be much more restrictive than previous standards and are based on sediment modeling and calibrated with actual GNF water quality data (instream suspended and bedload sediment), and sediment core (spawning substrate fines). This SFEIS analysis demonstrates that the BMW project in Hyalite and Bozeman Creek (both 6th level HUC's) would be considerably below and well within compliance with the 30% over natural standard. No HUC7 sediment analysis was appropriate in these watersheds. The only HUC7 modeling was done on Leverich Creek which for Alternative 2 and 3 exceed the 30% standard hence extensive mitigation was included to reduce Leverich sediment levels in the selected Alternative 6 to well within the sediment standards.

All Gallatin National Forest Plan standards that directly apply to BMW are fully met in the BMW project including Standards 10.2 (BMP's), 10.3 (cumulative effects analysis), and 10.10 (municipal watershed meeting water quality standards and project coordination with the City of Bozeman and State DEQ officials).

None of the streams in the BMW project area, including Bozeman Creek or Hyalite Creek, are 303(d) listed for sediment. The definition of "naturally occurring" allows some sediment and nutrient levels above natural providing "all reasonable land, soil, and water conservation practices have been applied" per ARM 16.20.603(11). The BMW BMPs use standard, or in many cases more stringent, BMP's than Montana Forestry BMP's or Montana SMZ rules and would meet the definition of "all reasonable". The Montana Code Annotated – 2007 75-5-703 section (10)(c) additionally specifies that "Pending completion of a TMDL on a water body listed pursuant to 75-5-303 new or expanded non-point source activities affecting a listed water-body may commence and continue if those activities are conducted in accordance with reasonable land, soil, and water conservation practices." This provision allows for small sediment increases and for Hyalite Creek nutrient increases associated with the BMW project since "reasonable" BMP's are being planned and required. In both cases the increases are minimal. The alternatives in the FEIS (p. 2-20) and recommendations on p. 178 meet these requirements. Broadcast burn buffer distances of both 50' and 100'are "reasonable" BMP's, although the 100' is slightly more effective. Mark Bostrom, Bureau Chief for Water Quality at Montana Department of Environmental Quality (DEQ), sent a letter to the Forest Service affirming the Bozeman Municipal Watershed (BMW) water quality best management practices (BMP) and concluded that the project is consistent with Montana water quality regulations.

As explained in the Affected Environment and Mitigation sections, all required water quality permits would be acquired by the Gallatin National Forest prior to any ground disturbance activities for the BMW. If logging road stormwater discharge NPDES permits are required for the BMW, the Gallatin National Forest will work with the Montana DEQ to obtain the permits prior to initiation of project implementation.

Unavoidable Adverse Effects

Changes between the Final EIS and the Supplemental FEIS.

The statement incorporates the most current effects analysis disclosure of short term adverse impacts on the FEIS p. 3-421.

Unavoidable adverse effects of this project are disclosed in the above "Issues" sections.

Consultation and Coordination

Changes between the Final EIS and the Supplemental FEIS.

The consultation and coordination information supplements the information in the FEIS. Some interdisciplinary team members changed due to retirements and transfers. Additional coordination with agencies and stakeholders is reflected in this supplement.

Interdisciplinary Team Members and Other Forest Service Specialists who Contributed

Scott Barndt, *Forest Fisheries Biologist* Gallatin National Forest, Bozeman MT	Acting Ecosystem Staff Officer Bachelor of Science (BS) Degree in Biology with Fisheries Emphasis Masters Degree in Biology with Fisheries Emphasis. 15 years experience in the field working for the Montana Fish Wildlife and Parks (MFWP), United States Fish and Wildlife Service (USFWS) and the US Forest Service.
Tim Brickell, *Fuels Specialist* Gallatin National Forest Bozeman MT	Zone Assistant Fire Management Officer. Bachelor of Science in Forest Resource Management, 27 years professional work experience in fire suppression, fuels management, and related fields for the US Forest Service.
Jodie Canfield, *Wildlife Biologist* Gallatin National Forest Bozeman MT	Forest Wildlife Biologist
Bev Dixon, *Wildlife Biologist and Sensitive Plants* Gallatin National Forest Bozeman, MT	Bozeman District Wildlife Biologist, BS, Business Management, Montana State U (1983); MS Fish and Wildlife Management, MSU (1997). *Work Experience*: 14 years (1983-1997) technical and administrative work in the Wildlife Resource Area, Gallatin National Forest; 13 years (1997-2010) professional experience as District Wildlife Biologist, Bozeman Ranger District. *Professional Membership*: Member, Montana Chapter The Wildlife Society 1983-2010, Chapter President 2001, Officer 2000-2002.
Fred Haas, *Recreation and Inventoried Roadless Specialist* Gallatin National Forest Bozeman, MT	District Resource Assistant for Recreation, Trails, Roads, Wilderness, Public Information program areas. BS in Forestry. Professional experience - 32 years with Forest Service working in timber, recreation, wilderness, mineral, range, trails and roads, lands, and special use permit management.
Tom Keck, *Forest Soil Scientist* Gallatin National Forest Bozeman, MT	Forest Soils Scientist and Reclamation Manager, Ph.D. in Soil Science from Montana State University in 1998, Masters Degree in Soil Science and Biometeorology from Utah State University in

	1983, Bachelors Degree in Forest Biology from Utah State University in 1979. Principal of Northern Rockies Soil and Water (an environmental science company), and Co-founder and Acting Chairman of the Board for Collin's Coalition, a non-profit organization. Nearly 20 years experience mapping soils as a Soil Scientist, Project Leader for the Natural Resources Conservation Service and instructor in Department of Land Resources and Environmental Sciences (LRES) at Montana State University soil science related subjects.
Susan Lamont, *Invasive Weeds, Economics and Vegetation Specialist* Gallatin National Forest West Yellowstone MT	West Zone Vegetation Program Manager including Range Management. Master Degree in Forest Management from Utah State University, Logan Utah 1991, 23 years Professional Work experience in this and related fields for the US Forest Service.
Mark Novak, *Vegetation and Silvicultural specialist* Gallatin National Forest Bozeman, MT	Forest Silviculturist, BS in Natural Resources, Silviculturist Certified, 30 Years Professional Work in various aspects of Forestrywith the US Forest Service and Bureau of Indian Affairs.
Bruce Roberts, *Fisheries and Aquatic Species Biologist* Gallatin National Forest Bozeman, MT	West Zone Fisheries Biologist BS in Fisheries Resources, Masters Degree in Fish Wildlife Management 22 years experience in the Fisheries Field with the US Forest Service.
Jane Ruchman, *Forest Landscape Architect* Gallatin National Forest Bozeman, MT	Forest Program Manager for Recreation Special Uses, Developed Recreation and Landscape Architecture.
Teri Seth *NEPA Team Leader* Gallatin National Forest Bozeman MT.	West Zone NEPA Coordinator BS Resource Conservation with Botany Minor 29 years experience in the fields of silviculture, timber management, special uses, ecosystem planning and NEPA with the USFS.
Julie Shea, *Forest and Fire Ecology* Gallatin National Forest Bozeman, MT	Forest Fire Planner and Silviculturist BS in Forestry.
Lisa Stoeffler, *Bozeman District Ranger* Gallatin National Forest Bozeman, MT	District Ranger for the Bozeman Ranger District
Mark Story, *Hydrologist* Gallatin National Forest Bozeman, MT	Forest Water and Air Quality Specialist B.S. in Wildlife Management, U of Wyoming, MS in Watershed Management, U. of Arizona. 36 years of experience in water resources and 27 years of experience in air quality for the US Forest Service in Arizona, Wyoming, Colorado, and Montana.

Preparers and Contributors

The Forest Service consulted the following individuals, Federal, State, and local agencies, tribes and non-Forest Service persons during the development of this environmental assessment:

Federal, State, and Local Agencies

City of Bozeman Commission

City of Bozeman Staff, Public Works Division

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Eric Campbell, Bozeman Water Treatment Operation Foreman, Bozeman MT

Brian Heaston, Engineer

Montana Fish, Wildlife and Parks, Bozeman, MT

Alt, Kurt. Wildlife Manager. Montana Fish Wildlife and Parks. Bozeman, MT (Pers. Comm. 2009)

Cunningham, Julie, Wildlife Biologist. Montana Fish Wildlife and Parks. Bozeman, MT (Pers. Comm. 2010)

Jourdonnais, Craig. Wildlife Biologist. Montana Fish Wildlife and Parks. Bozeman, MT.(Pers. Comm. 2007, 2008)

Montana Department of Natural Resources, Bozeman Unit. Craig Campbell. Bozeman, MT.

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Lisa Kusniez, Water Quality Planner, EPA, Helena, MT.

Robert Ray, Section Supervisor, Watershed Protection Section, Montana DEQ, Helena MT

Pete Schade, Senior Water Quality Planner, Watershed Management Section, Montana DEQ, Helena MT

Sourdough-Rae Fire Department, Bozeman, MT.USFS, Bruce Sims, R1 Regional Hydrologist, USFS, Missoula MT

USFS, Peter Zimmerman, Regional NEPA, Appeals and Litigation Specialist, Missoula, MT

Tribes

Crow Tribe – Burial Preservation, Mr. William Big Day, Pryor MT

Others:

Alliance for Wild Rockies, Helena, MT.

Greater Yellowstone Coalition, Bozeman, MT.

RY Lumber, Townsend, MT.

Native Ecosystems Council, Willow Creek, MT.

Distribution of the Supplemental Final Environmental Impact Statement

Approximately 200 individuals, businesses, local and state government agency representatives and advocacy organizations were sent a summary of and notice that the SFEIS is available for public review during the week of February 14, 2011. All Federal agencies that require notice of EIS's (12) for this type of project and this region were also sent notice of avaiabilty. The SFEIS will be avaiable for review on the Gallatin Forest Webpage the week of February 14, 2011. The document will be filed under the Land & Resource Management link in the Projects folder at The Gallatin Forest Webpage:

www.fs.usda.gov/gallatin

This supplemental final environmental impact statement will be distributed to individuals who specifically requested a copy of the document and those who submitted substantive comments on the draft environmental impact statement. In addition, copies will be sent to the following Federal agencies, federally recognized tribes, State and local governments, and organizations representing a wide range of views regarding fuel reduction treatments in the Municipal watershed and wildland urban interface for Bozeman, Montana.

Environmental Protection Agency
USDA National Agricultural Library
Office of Environmental Policy and Compliance, DOI
Montana Department of Environmental Quality, Helena, MT.
City of Bozeman, Commission and Public Works Staff
Crow Tribe – Burial Preservation, Mr. William Big Day
Kenneth Zahn, Bozeman, MT.
Phil Knight, Bozeman, MT.
Greater Yellowstone Coalition, Bozeman, MT.
Wilderness Society, Bozeman, MT.
Alliance for the Wild Rockies, Helena, MT.
Native Ecosystems Council, Willow Creek Forks, MT.

Literature Cited

Changes between the Final EIS and the Supplemental FEIS.

These references replace the literature cited for Elk and Other Big Games species, Fisheries and Aquatic Species, Soils and Water Quality.

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Peck, Gary. August 2009 City of Bozeman Forest Management Plan. Bozeman, MT.

Elk and Other Big Game

Personal Communications Cited

Alt, Kurt. Region 3 Wildlife Manager, Montana Fish, Wildlife, and Parks. Bozeman, Montana

Cunningham, Julie. Wildlife Biologist, Montana Fish Wildlife and Parks, Bozeman, Montana

Jourdonnais, Craig. Wildlife Biologist, Montana Fish Wildlife and Parks, Bozeman, Montana

Tyers, Dan. Wildlife Biologist, Gardiner Ranger District, USDA Forest Service.

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Appendix A – Soil and Water Best Management Practices[5]

Changes between the FEIS and SFEIS.

This Appendix replaces Appendix B of the FEIS. The soil best management practices have been updated slightly based on knowledge gained during soil transects and soil monitoring in the project area last summer and fall (2010). The water quality protections have not changed.

The soil best management practices have been updated slightly. The water quality protections have not changed.

Soil Protection Practices

Gallatin National Forest Soil Mitigations and Best Management Practices

Skid Trail Placement and Slope Limitations

Require a systematic skid trail pattern during logging. Mechanical ground-based skidding and harvesting equipment may be used off of skid trails only to the degree necessary to harvest the available timber and only when soil moisture conditions are favorable. (See below for details.)

Use ground-based harvest systems only on slopes having sustained grades less than 35 percent.

Maintain an average of at least 75 feet between skid trails in all tractor harvested partial cuts and an average of 100 feet in all tractor harvest clearcuts. Skid trails may be closer than this spacing where converging so long as the overall spacing averages 75 feet and 100 feet, respectively.

Lay out skid trails in a manner that minimizes or, where possible, eliminates sustained grades steeper than 15%. This recommendation is expanded to include grades steeper than 8% on the most erosion prone soils, i.e.: *coarse textured soils over shallow bedrock*.

Avoid placing skid trails or temporary roads over convex knobs or along narrow, rocky ridges (areas least able to recover from disturbance) to the extent possible.

[5] **Monitoring is planned for all BMP's as a standard practice on the Gallatin National Forest. When monitoring results indicate the need to revise Best Management Practices to improve effectiveness or to eliminate ineffectice practices it is assumed that all project related BMP's will be updated to incorporate the most current knowledge and practices.

Temporary Road Construction and Re-use of Existing Roads, Landings, and Skid Trails

Minimize the depth of blading in construction of temporary roads within the constraints of standard Forest Service practices for temporary road construction.

Re-use existing temporary roads, landings, and skid trails in previously harvested areas to the extent practical.

Use of Skidding and Harvesting Equipment Off Skid Trails (non-winter harvesting)

Ground based skidding equipment may travel off of the established skid trails but only to the extent reasonably necessary to harvest timber based on the sale administrator's judgment and only when the top 6 inches of soil will not form a ribbon between the thumb and forefinger.** (Criteria integrates the combined influence of soil texture and soil moisture – *see USDA Technical Guide for Estimating Soil Moisture (USDA, NRCS 1998)*) Repeat passes over the same ground should be minimized.

Feller/buncher/mechanical harvesters may be used off established skid trails to the extent reasonably necessary to harvest timber but only when the top six inches of soil will either not form a ball when squeezed in the palm of a hand or will only form a weak ball and at most will form a weak ribbon between the thumb and forefinger.** (*Criteria integrates soil texture and soil moisture effects and is slightly more restrictive than the criteria for skidding equipment – see USDA Estimating Soil Moisture Tech. Guide(USDA, NRCS 1998))* Repeat passes over the same ground should be minimized.

*** Soil scientist for the GNF will be actively involved in the implementation of these provisions.*

Winter Harvesting Restrictions – No winter harvesting is planned for BMW but winter logging is permissible.

Tractor harvesting over snow or frozen ground in the winter should be limited to periods when there is a minimum of 8 inches of settled snow covering the ground or, in the absence of sufficient snow, when the top four inches of mineral soil is either frozen or dry. Harvesting should not proceed if ponding occurs at the mineral soil surface due to partial thawing of a surface frost layer. Previously noted limitations to equipment use off skid trails based on soil texture and moisture conditions and the need for a systematic skid trail system do not apply to winter harvesting providing the settled snow depth or frozen ground criteria are met.

Landings, Temporary Roads, and Skid Trail Remediation

Landings --- Cut and fill slopes, if present, around the margins of landings may be re-contoured if soils are non-skeletal *(have less than 35% rock fragments in the subsoil)*. The landing base should be ripped to a depth of at least 6 inches subject to the following: 1) Scarification (ripping) of landings with burn piles only needs to be completed on exposed portions of the landing surrounding the burn pile, 2) The scarification (ripping) requirement may be waived on soils having abundant rock fragments in the top 6 inches of soil; defined as 20 percent or more 3 inch or larger rock fragments or more than 50 percent rock fragments overall.

Temporary Roads --- Cut and fill slopes, where present, may require re-contouring if soils are non-skeletal *(have less than 35% rock fragments in the subsoil)*. In all other areas, the road prism should be scarified (ripped) to a minimum depth of 6 inches into the mineral soil. This requirement may be waived on soils having abundant large rock fragments in the top 6 inches of soil; defined as 20 percent or more 3 inch or larger rock fragments or more than 50 percent rock fragments overall.

Skid Trails --- Scarification (ripping) will not be required on skid trails except in areas where the soil is detrimentally compacted and mineral soil is exposed at the surface or where wheel ruts have formed at least 2 inches deep on grades steeper than 15% or continuous to grades steeper than 15%. Detrimental compaction, as defined by the Detrimental Soil Disturbance Standards for the Gallatin National Forest, has a combined thickness of 2 inches of significant compaction in the top 4 inches of soil, 3 inches in the top 8 inches of soil, or 4 inches in the top 12 inches of soil.

Logging Slash and Other Woody Debris

Leave at least 15 tons per acre of coarse woody debris (3" inch or larger clearing or logging slash) behind in clearcut units and 10 tons per acre in partial cutting units (less than 60% canopy cover removed), when available. Coarse woody debris protect the soil surface, slow surface runoff, and return soil nutrients to the soil. The coarse woody debris requirement in specific instances of forest stands growing on dry, south facing slopes or on high organic matter soils may be reduced to 12 tons/acre for clearcuts and 8 tons/acre for partial cuts.

Slash at an approximate rate of 15 tons per acre should be placed across skid trails in areas of steeper (>15%) slopes at the completion of logging. Lopping off at least some of the branches to get better contact with the ground surface increases the soil remediation effectiveness of this treatment.

Leave some unmerchantable material standing adjacent to temporary roads and landings, where reasonable, during harvesting. This material will be used for slashing these areas by Forest Service personnel at the end of the project.

Finally, leave the logs and brush to be burned by the Forest Service at landings in more of a mounded pile than a steep sided, dozer pile. This will facilitate Forest Service personnel pulling some material out of the pile prior to burning. Brush removed will be used for slashing the area of the burn pile at the completion of burning.

Water Quality - Best Management Practices, Riparian Treatment Strategies and Streamside Management Zone Guidelines for the Bozeman Municipal Watershed Project.

Best Management Practices for Forestry in the State of Montana (MDNRC)

January 2006

I. DEFINITIONS

1. "Hazardous or toxic material" means substances which by their nature are dangerous to handle or dispose of, or a potential environmental contaminant, and includes petroleum products, pesticides, herbicides, chemicals, and biological wastes.

2. "Stream," as defined in 77-5-302(7), MCA, means a natural water course of perceptible extent that has a generally sandy or rocky bottom or definite banks and that confines and conducts continuously or intermittently flowing water.

3. "Streamside Management Zone (SMZ)" or "zone" as defined at 77-5-302(8),

MCA means "the stream, lake, or other body of water and an adjacent area of varying width where management practices that might affect wildlife habitat or water quality, fish, or other aquatic resources need to be modified." The streamside management zone encompasses a strip at least 50 feet wide on each side of a stream, lake, or other body of water, measured from the ordinary high water mark, and extends beyond the high water mark to include wetlands and areas that provide additional protection in zones with steep slopes or erosive soils.

4. "Wetlands" mean those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands include marshes, swamps, bogs, and similar areas.

5. Adjacent wetlands are wetlands within or adjoining the SMZ boundary. They are regulated under the SMZ law.

6. Isolated wetlands lie within the area of operation, outside of the SMZ boundary, and are not regulated under the SMZ law.

II. STREAMSIDE MANAGEMENT

The Streamside Management Law (77-5-301 through 307 MCA) provides minimum regulatory standards for forest practices in streamside management zones (SMZ). The "Montana Guide to the Streamside Management Zone & Rules" is an excellent information source describing management opportunities and limitations within SMZs.

III. ROADS

A. Planning and Location

1. Minimize the number of roads constructed in a watershed through comprehensive road planning, recognizing intermingled ownership and foreseeable future uses. Use existing roads, unless use of such roads would cause or aggravate an erosion problem.

2. Review available information and consult with professionals as necessary to help identify erodible soils and unstable areas, and to locate appropriate road surface materials.

3. Fit the road to the topography by locating roads on natural benches and following natural contours. Avoid long, steep road grades and narrow canyons.

4. Locate roads on stable geology, including well-drained soils and rock formations that tend to dip into the slope. Avoid slumps and slide prone areas characterized by steep slopes, highly weathered bedrock, clay beds, concave slopes, hummocky topography, and rock layers that dip parallel to the slope. Avoid wet areas, including moisture laden or unstable toe slopes, seeps, wetlands, wet meadows, and natural drainage channels.

5. Minimize the number of stream crossings and choose stable stream crossing sites.

6. Locate roads to provide access to suitable (relatively flat and well drained) log landing areas to reduce soil disturbance.

B. Design

1. Properly design roads and drainage facilities to prevent potential water quality problems from road construction.

2. Design roads to the minimum standard necessary to accommodate anticipated use and equipment. The need for higher engineering standards can be alleviated through proper road-use management.

3. Design roads to balance cuts and fills or use full bench construction (no fill slope) where stable fill construction is not possible.

4. Design roads to minimize disruption of natural drainage patterns. Vary road grades to reduce concentrated flow in road drainage ditches, culverts, and on fill slopes and road surfaces.

C. Road Drainage

Road Drainage is defined as all applied mechanisms for managing water in a non-stream crossing setting, road surface drainage, and overland flow; ditch relief, cross drains and drain dips).

1. Provide adequate drainage from the surface of all permanent and temporary roads. Use out sloped, in sloped or crowned roads, and install proper drainage features. Space road drainage features so peak flow on road surfaces or in ditches will not exceed capacity.

a. Outsloped roads provide a means of dispersing water in a low energy flow from the road surface. Outsloped roads are appropriate when fill slopes are stable, drainage will not flow directly into stream channels, and transportation safety can be met.

b. For in-sloped roads, plan ditch gradients steep enough, generally greater than 2% but less than 8%, to prevent sediment deposition and ditch erosion. The steeper gradients may be suitable for more stable soils; use the lower gradients for less stable soils.

c. Design and install road surface drainage features at adequate spacing to control erosion; steeper gradients require more frequent drainage features. Properly constructed drain dips can be an economical method of road surface drainage. Construct drain dips deep enough into the subgrade so that traffic will not obliterate them.

2. Design all ephemeral draw culverts with adequate length to allow for road fill width. Minimum culvert size is 15 inch. Install culverts to prevent erosion of fill, seepage and failure as described in V.C.4 and maintain cover for culverts as described in V.C.6.

3. Design all relief culverts with adequate length to allow for road fill width. Protect the inflow end of all relief culverts from plugging and armor if in erodible soil. When necessary construct catch basins with stable side slopes. Unless water flows from two directions, skew ditch relief culverts 20 to 30 degrees toward the inflow from the ditch to help maintain proper function.

4. Where possible, install culverts at the gradient of the original ground slope; otherwise, armor outlets with rock or anchor downspouts to carry water safely across the fill slope.

5. Provide energy dissipaters (rock piles, slash, log chunks, etc.) where necessary to reduce erosion at outlet of drainage features. Cross drains, culverts, water bars, dips, and other drainage structures should not discharge onto erodible soils or fill slopes without outfall protection.

6. Prevent downslope movement of sediment by using sediment catch basins, drop inlets, changes in road grade, headwalls, or recessed cut slopes.

7. Route road drainage through adequate filtration zones or other sediment-settling structures to ensure sediment doesn’t reach surface water. Install road drainage features above stream crossings to route discharge into filtration zones before entering a stream.

D. Construction (see also Section V on stream crossings)

1. Keep slope stabilization, erosion and sediment control work current with road construction. Install drainage features as part of the construction process, ensuring that drainage structures are fully functional. Complete or stabilize road sections within same operating season.

2. Stabilize erodible, exposed soils by seeding, compacting, riprapping, benching, mulching, or other suitable means.

3. At the toe of potentially erodible fill slopes, particularly near stream channels, pile slash in a row parallel to the road to trap sediment (example, slash filter windrow). When done concurrently with road construction, this is one method that can effectively control sediment movement, and it can also provide an economical way of disposing of roadway slash. Limit the height, width and length of "slash filter windrows" so wildlife movement is not impeded. Sediment fabric fences or other methods may be used if effective.

4. Minimize earthmoving activities when soils appear excessively wet. Do not disturb roadside vegetation more than necessary to maintain slope stability and to serve traffic needs.

5. Construct cut and fill slopes at stable angles to prevent sloughing and other subsequent erosion.

6. Avoid incorporating potentially unstable woody debris in the fill portion of the road prism. Where possible, leave existing rooted trees or shrubs at the toe of the fill slope to stabilize the fill.

7. Consider road surfacing to minimize erosion.

8. Place debris, overburden, and other waste materials associated with construction and maintenance activities in a location to avoid entry into streams. Include these waste areas in soil stabilization planning for the road.

9. Minimize sediment production from borrow pits and gravel sources through proper location, development and reclamation.

10. When using existing roads, reconstruct only to the extent necessary to provide adequate drainage and safety; avoid disturbing stable road surfaces. Prior to reconstruction of existing roads within the SMZ, refer to the SMZ law. Consider abandoning existing roads when their use would aggravate erosion.

E. Maintenance

1. Grade road surfaces only as often as necessary to maintain a stable running surface and adequate surface drainage.

2. Maintain erosion control features through periodic inspection and maintenance, including cleaning dips and cross drains, repairing ditches, marking culvert inlets to aid in location, and clearing debris from culverts.

3. Avoid cutting the toe of cut slopes when grading roads, pulling ditches, or plowing snow.

4. When plowing snow, provide breaks in snow berm to allow road drainage.

5. Haul all excess material removed by maintenance operations to safe disposal sites and stabilize these sites to prevent erosion. Avoid side casting in locations where erosion will carry materials into a stream.

6. Avoid using roads during wet periods if such use would likely damage the road drainage features. Consider gates, barricades or signs to limit use of roads during spring break up or other wet periods.

7. Upon completion of seasonal operations, ensure that drainage features are fully functional. The road surface should be crowned, outsloped, insloped, or water-barred. Remove berms from the outside edge where runoff is channeled.

8. Leave abandoned roads in a condition that provides adequate drainage without further maintenance. Close these roads to traffic; reseed and/or scarify; and, if necessary, recontour and provide water bars or drain dips.

IV. TIMBER HARVESTING, AND SITE PREPARATION

A. Harvest Design

1. Plan timber harvest in consideration of your management objectives and the following:

    a. Soils and erosion hazard identification.

    b. Rainfall.

    c. Topography.

    d. Silvicultural objectives.

    e. Critical components (aspect, water courses, landform, etc.).

    f. Habitat types.

    g. Potential effects on water quality and beneficial water uses.

    h. Watershed condition and cumulative effects of multiple timber management activities on water yield and sediment production.

    i. Wildlife habitat.

2. Use the logging system that best fits the topography, soil type, and season, while minimizing soil disturbance and economically accomplishing silvicultural objectives.

3. Use the economically feasible yarding system that will minimize road densities.

4. Design and locate skid trails and skidding operations to minimize soil disturbance. Using designated skid trails is one means of limiting site disturbance and soil compaction. Consider the potential for erosion and possible alternative yarding systems prior to planning tractor skidding on steep or unstable slopes.

5. Locate skid trails to avoid concentrating runoff and provide breaks in grade. Locate skid trails and landings away from natural drainage systems and divert runoff to stable areas. Limit the grade of constructed skid trails on geologically unstable, saturated, highly erosive, or easily compacted soils to a maximum of 30%. Use mitigating measures, such as water bars and grass seeding, to reduce erosion on skid trails.

6. Minimize the size and number of landings to accommodate safe, economical operation. Avoid locating landings that require skidding across drainage bottoms.

B. Other Harvesting Activities

1. Tractor skid where compaction, displacement, and erosion will be minimized. Avoid tractor or wheeled skidding on unstable, wet, or easily compacted soils and on slopes that exceed 40% unless operation can be conducted without causing excessive erosion. Avoid skidding with the blade lowered. Suspend leading ends of logs during skidding whenever possible.

2. Avoid operation of wheeled or tracked equipment within isolated wetlands, except when the ground is frozen (see Section VI on winter logging).

3. Use directional felling or alternative skidding systems for harvest operations in isolated wetlands.

4. For each landing, provide and maintain a drainage system to control the dispersal of water and to prevent sediment from entering streams.

5. Insure adequate drainage on skid trails to prevent erosion. On gentle slopes with slight disturbance, a light ground cover of slash, mulch or seed may be sufficient. Appropriate spacing between water bars is dependent on the soil type and slope of the skid trails. Timely implementation is important.

6. When existing vegetation is inadequate to prevent accelerated erosion, apply seed or construct water bars before the next growing season on skid trails, landings and fire trails. A light ground cover of slash or mulch will retard erosion.

C. Slash Treatment and Site Preparation

1. Rapid reforestation of harvested areas is encouraged to reestablish protective vegetation.

2. When treating slash, care should be taken to preserve the surface soil horizon by using appropriate techniques and equipment. Avoid use of dozers with angle blades.

3. Minimize or eliminate elongated exposure of soils up and down the slope during mechanical scarification.

4. Scarify the soil only to the extent necessary to meet the resource management objectives. Some slash and small brush should be left to slow surface runoff, return soil nutrients, and provide shade for seedlings.

5. Carry out brush piling and scarification when soils are frozen or dry enough to minimize compaction and displacement.

6. Carry out scarification on steep slopes in a manner that minimizes erosion. Prescribed burning and/or herbicide application is preferred means for site preparation, especially on slopes greater than 40%.

7. Remove all logging machinery debris to proper disposal site.

8. Limit water quality impacts of prescribed fire by constructing water bars in firelines; not placing slash in drainage features and avoiding intense fires unless needed to meet silvicultural goals. Avoid slash piles in the SMZ when using existing roads for landings.

V. STREAM CROSSINGS

A. Legal Requirements

1. Under the Natural Streambed and Land Preservation Act of 1975 (the "310 law"), any activity that would result in physical alteration or modification of a perennial stream, its bed or immediate banks must be approved in advance by the supervisors of the local conservation district. Permanent or temporary stream crossing structures, fords, rip rapping or other bank stabilization measures, and culvert installations on perennial streams are some of the forestry-related projects subject to 310 permits. Before beginning such a project, the operator must submit a permit application to the conservation district indicating the location, description, and project plans. The evaluation generally includes onsite review, and the permitting process may take up to 60 days.

2. Stream-crossing projects initiated by federal, state or local agencies are subject to approval under the "124 permit" process (administered by the Department of Fish, Wildlife and Parks), rather than the 310 permit.

3. A short-term exemption (3a authorization) from water quality standards is necessary unless waived by the Department of Fish, Wildlife and Parks as a condition of a 310 or 124 permit. Contact the Department of Environmental Quality in Helena at 444-2406 for additional information.

B. Design Considerations (Note: 310 permit required for perennial streams)

1. Cross streams at right angles to the main channel if practical. Adjust the road grade to avoid the concentration of road drainage to stream crossings. Direct drainage flows away from the stream crossing site or into an adequate filter.

2. Avoid unimproved stream crossings. Depending on location, culverts, bridges and stable/reinforced fords may be used.

C. Installation of Stream Crossings (Note: 310 permit required for perennial streams)

1. Minimize stream channel disturbances and related sediment problems during construction of road and installation of stream crossing structures. Do not place erodible material into stream channels. Remove stockpiled material from high water zones. Locate temporary construction bypass roads in locations where the stream course will have minimal disturbance. Time construction activities to protect fisheries and water quality.

2. Design stream-crossings for adequate passage of fish (if present) with minimum impact on water quality. When using culverts to cross small streams, install those culverts to conform to the natural stream bed and slope on all perennial streams and on intermittent streams that support fish or that provides seasonal fish passage. Ensure fish movement is not impeded. Place culverts slightly below normal stream grade to avoid outfall barriers.

3. Do not alter stream channels upstream from culverts, unless necessary to protect fill or to prevent culvert blockage. On stream crossings, design for, at a minimum, the 25-year frequency runoff. Consider oversized pipe when debris loading may pose problems.

Ensure sizing provides adequate length to allow for depth of road fill.

4. Install stream-crossing culverts to prevent erosion of fill. Compact the fill material to prevent seepage and failure. Armor the inlet and/or outlet with rock or other suitable material where feasible.

5. Consider dewatering stream crossing sites during culvert installation.

6. Maintain a 1-foot minimum cover for stream-crossing culverts 15 to 36 inches in diameter, and a cover of one-third diameter for larger culverts, to prevent crushing by traffic.

7. Use culverts with a minimum diameter of 15 inches for permanent stream crossings.

D. Existing Stream Crossings

1. Ensure stream crossing culverts have adequate length to allow for road fill width and are maintained to preserve their hydrologic capacity. To prevent erosion of fill, provide or maintain armoring at inlet and/or outlet with rock or other suitable material where feasible. Maintain fill over culvert as described in V.C. 6.

VI. WINTER LOGGING

A. General

1. Consider snow-road construction and winter harvesting in isolated wetlands and other areas with high water tables or soil erosion and compaction hazards.

2. Conduct winter logging operations when the ground is frozen or snow cover is adequate (generally more than one foot) to prevent rutting or displacement of soil. Be prepared to suspend operations if conditions change rapidly, and when the erosion hazard becomes high.

3. Consult with operators experienced in winter logging techniques.

B. Road Construction and Harvesting Considerations

1. For road systems across areas of poor bearing capacity, consider hauling only during frozen periods. During cold weather, plow any snow cover off of the roadway to facilitate deep freezing of the road grade prior to hauling.

2. Before logging, mark existing culvert locations. During and after logging, make sure that all culverts and ditches are open and functional.

3. Use compacted snow for road beds in unroaded, wet or sensitive sites. Construct snow roads for single-entry harvests or for temporary roads.

4. In wet, unfrozen soil areas, use tractors or skidders to compact the snow for skid road locations only when adequate snow depth exists. Avoid steeper areas where frozen skid trails may be subject to erosion the next spring.

5. Return the following summer and build erosion barriers on any trails that are steep enough to erode.

VII. HAZARDOUS SUBSTANCES

A. General

1. Know and comply with regulations governing the storage, handling, application (including licensing of applicators), and disposal of hazardous substances. Follow all label instructions.

2. Develop a contingency plan for hazardous substance spills, including cleanup procedures and notification of the State Department of Environmental Quality.

B. Pesticides and Herbicides

1. Use an integrated approach to weed and pest control, including manual, biological, mechanical, preventive and chemical means.
2. To enhance effectiveness and prevent transport into streams, apply chemicals during appropriate weather conditions (generally calm and dry) and during the optimum time for control of the target pest or weed.

Riparian Treatment Strategies for the Bozeman Municipal Watershed Project

Stream Class Definitions

<u>Class 1</u> streams support fish or surface flow during six months of the year or more and contribute surface flow to another stream, lake, or other body of water.

<u>Class 2</u> streams normally do not have surface flow six months of the year, but do contribute surface flow to another stream, lake or other bodies of water or streams that normally do have surface flow six months of the year, but do not contribute surface flow to another stream, lake or other bodies of water.

<u>Class 3</u> streams rarely contribute surface flow to other streams or other bodies of water, and normally do not have surface flow six months of the year or more. These streams are typically not connected to other streams.

Riparian Treatment Strategies

Class 1 Fish Bearing Streams

Above Intakes and Leverich Creek

Helicopter Logging – 100 foot no cut buffer

Ground Base Logging, Slashing or Piling (Cable, Tractor or Excavator) - 100 foot no cut buffer

Broadcast Burning - 50 foot no ignition buffer for Alt. 5 and 6

Below Intakes

Helicopter Logging – Not Applicable

Ground Base Logging, Slashing or Piling (Cable, Tractor or Excavator) – Not Applicable

Broadcast Burning - Not Applicable

Class 1 Non-Fish Bearing Streams

Above Intakes and Leverich Creek

Helicopter Logging – Modified SMZ Guidelines

Ground Base Logging, Slashing or Piling (Cable, Tractor or Excavator) - 100 foot no cut buffer

Broadcast Burning - 50 foot no ignition buffer for Alt. 5 and 6

Below Intakes

Helicopter Logging – Modified SMZ Guidelines

Ground Base Logging, Slashing or Piling (Cable, Tractor or Excavator) – Modified SMZ Guidelines

Broadcast Burning - 50 foot no ignition buffer

Class 2 Streams

Above Intakes and Leverich Creek

Helicopter Logging – Modified SMZ Guidelines

Ground Base Logging, Slashing or Piling (Tractor or Excavator) - 100 foot no cut buffer

Ground based logging (Cable) - Modified SMZ guidelines.

Broadcast Burning – No ignition buffer

Below Intakes

Helicopter Logging – Modified SMZ Guidelines

Ground Base Logging, Slashing or Piling (Cable, Tractor or Excavator) – Modified SMZ Guidelines

Broadcast Burning – No ignition buffer

Class 3 Streams

Above Intakes and Leverich Creek

Helicopter Logging – Not Applicable

Ground Base Logging, Slashing or Piling (Cable, Tractor or Excavator) – Not Applicable

Broadcast Burning – Not Applicable

Below Intakes

Helicopter Logging – Not Applicable

Ground Base Logging, Slashing or Piling (Cable, Tractor or Excavator) – SMZ Guidelines

Broadcast Burning – No buffer

No Cut or Treatment Buffers

No trees would be removed or fuels treated within designated buffers adjacent to stream channels as measured from the ordinary highwater marks. The width of these buffers would vary depending on proposed treatment and location.

Modified SMZ Guidelines

These additional protections were developed in coordination with The Gallatin Madison Chapter of Trout Unlimited to better meet the intent of the Trout

Unlimited Settlement Agreement to the Gallatin Forest Plan 1987 and to ensure riparian protection.

No trees would be cut within 15 feet of the Ordinary High Water Mark (OHWM) along any fish bearing Class 1 or Class 2 stream segments within commercial and non-commercial treatment units. Removal of lower branches (or ladder fuels) of larger trees within this 15 foot no cut zone would be allowed if removal would not result in mortality to that tree. This mitigation measure is designed to protect streambanks, provide thermal regulation overhead cover, augment debris recruitment, and reduce or prevent sediment delivery.

Retain all bank-edge trees maintaining stable stream banks and trees leaning toward streams that can provide large woody debris within commercial and non-commercial treatment units.

A fisheries biologist or trained fisheries technician be present during the marking of all commercial or non-commercial treatment unit boundaries adjacent to streams and marking of leaning leave trees outside the 15 foot no cut zone.

SMZ Guidelines

Equipment operation would be prohibited within the 50 foot wide SMZ's. SMZ boundaries would be clearly marked along on all stream segments.

Trees cut and removed within the 50 foot wide SMZ would be directionally fell and cabled out.

Bank-edge trees would be favored.

Trees leaning toward streams would be favored.

Sub-merchantable trees and shrubs would be retained and protected to the fullest extent possible.

Hardwoods and snags may be counted toward the retention tree requirements in approximately the same proportion as in the pre-harvest stand.

For Class 2 streams, retain at least 50% of trees greater than or equal to 8 inches DBH on each side of stream or 5 trees per 100 foot segment, whichever is greater. Note: Proposed buffers adjacent to fish bearing Class1 streams exceed what is required by SMZ compliance rules.

All trees that have fallen through natural processes, across or in a Class 1 or 2 stream must be retained.

A fisheries biologist or trained fisheries technician be given the discretion to widen the no cut buffers to protect stream channels and riparian resources if the no cut buffers (15, 50, or 100 feet) are deemed inadequate.